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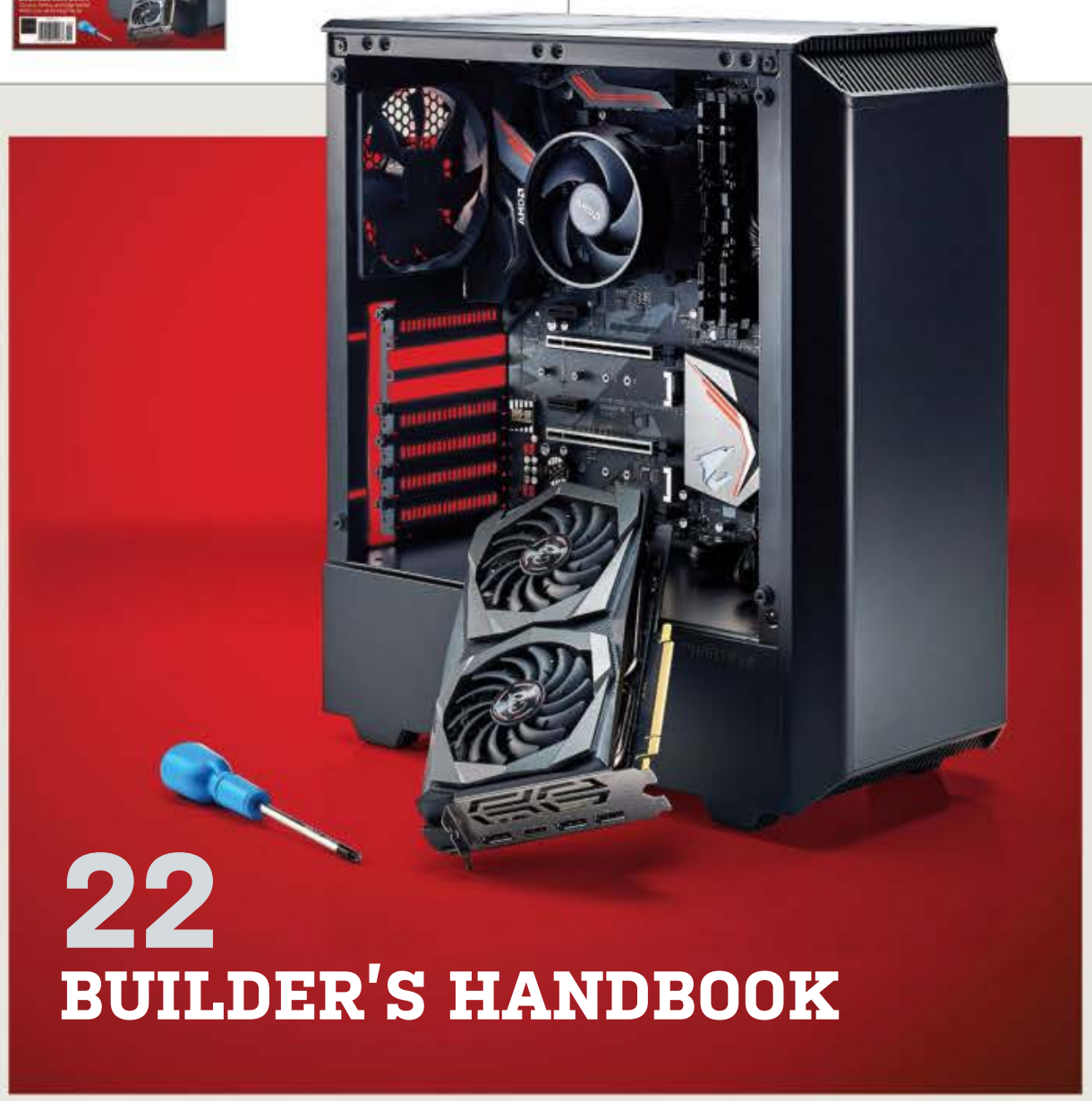

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Zak Storey

BACK TO THE BASICS

LIFE'S A TOUGH OLD GIG right now, that's for sure. The economy's in the dumps, borders are closed, travel's restricted, and *Maximum PC* hasn't escaped from any of it. Sadly we've taken another hit on the chin this month, and management has scaled back our budgets to help keep us all employed and insured. That does mean that, for the time being at least, we've lost some of the columns from our regular writers. As I said last issue, this is only temporary, and I do want to stress to you that we're doing all we can to ensure that our freelancers and their families are well supported during this time. I've also been assured that we should be back to full strength—budgets, page-counts, writers, and all—very soon.

On top of that, I do hope that you're all keeping safe and well out there. As my old pops always says, as long as you've got a roof over your head and food in your stomach, you're doing all right, just keep going. And what better time is there than now to bury your head into the latest issue of *Maximum PC* and escape the drudgery of what everyday life has become.

It's a funny thing. We planned this issue even before COVID-19 really hit. Because, to be honest, this is the direction I want to push this magazine. Building systems is a big part of what makes being a PC enthusiast so great. Budgets vary, hardware varies, and system specs change dynamically depending on the will of the builder, and it's a big part of why the custom PC is so important and so versatile in our society. Take Folding@home as an example. At the time of writing, it currently has more processing power than the top 500 supercomputers in the world combined. But unlike those multi-million dollar glorified server farms, it's made up of an army of all different types of PCs, many of which would've been built by enthusiasts like us, with wholly different purposes in mind from rig to rig.

That's why it's so important every now and then to get back to the basics and really brush up on what makes this hobby so special; system building. This issue we have a big 10-page feature on our best tips and tricks to amp up your build experience. On top of that, we also have a fantastic look into the future of integrated graphics, and a deep dive into the world of Internet browsers, which covers everything from privacy to performance benchmarks, and more. In fact, it's even convinced this editor to ditch Chrome for Firefox, and that certainly ain't nothing.

On top of that, we're also expanding our build-it coverage permanently, increasing it to six pages each and every issue, to give you a better look at our monthly featured system. This time around we're seeing just what you can create with a $2,000(ish), budget, and a 1440p, 60 frames-per-second goal to aim for.

As always, I hope you enjoy this issue, please do stay safe, and I look forward to seeing you all on the other side.

Zak Storey is Maximum PC's *editor and long-time staff member. He's been building PCs since he was 10, and is more than capable of butting heads with the biggest names in tech.*

↘ submit your questions to: comments@maximumpc.com

THE NEWS

Rocket Lake

Intel's rumored next big thing

SINCE AMD launched Ryzen, Intel has been floundering a little. We've waited and waited to see what the blue team would do. We've had improved chips, but nothing to match the splash the Zen core made. Intel has a new core design, Sunny Cove (that's developed into Willow Cove), but you'll struggle to find one outside a laptop. We've also now had four iterations of Skylake—it was a good design, but this can't last.

Things are currently fairly quiet, for obvious reasons—we still haven't even had the official launch of the 10th-generation Comet Lake desktop chips. This leaves us with rumor and speculation, fueled by some intriguing leaks. Be warned though: Intel is an old hand at managing such things, so we must proceed with some caution.

The hot gossip is centered on the 11th-generation Rocket Lake. Recent snippets from inside Intel (apparently) have given us something to work on. Rocket Lake is a new core architecture, based around Willow Cove (Intel uses a lot of code names). It will still be a 14nm chip, but will use a design originally destined for 10nm parts. This is a practical response to the difficulties Intel has experienced getting 10nm production going. It makes sense: the 10nm Sunny/Willow Cove family aren't ready, so why not make them using the trusty 14nm process? It may also help keep clock speeds high, which Intel has been good at in previous 14nm parts. Ice Lake (Sunny Cove's first outing) proved difficult to clock.

Rocket Lake will also feature PCIe 4.0, which is most welcome, as AMD has this on the Ryzen 3000-series. Even better, is that it has 20 lanes, so you can run your graphics card at the full x16, and have a x4 link for your NVMe drive, which can now sit on the right side of the motherboard bus. The Direct Media Interface (DMI) also gets an upgrade. Depending on which source you follow, this will be DMI 4.0, or a DMI 3.0 x8 instead of x4. Either way, it will double the theoretical bandwidth, smoothing this notorious bottleneck.

The leaked slides we've seen still show the 500-series motherboard chipset using PCIe 3.0 however, 24 lanes of them. You do get USB 3.2 as well, which runs at 20GB/sec, aka Thunderbolt 4.0, and DisplayPort reaches version 1.4a.

> Rocket Lake is due for release next year, probably.

We've no picture of Rocket Lake, so here's a rocket. If the rumors prove true Intel will have a solid answer to AMD's Ryzen.

The integrated graphics are being completely overhauled, and will be based on the Intel Xe architecture. Intel made clear it had big plans for this, right from the simplest to the high-end parts. This probably will be on 10nm silicon. Intel has been pushing the idea of mixing chips together using its Foveros system, first seen in the Lakefield hybrid chip. The Xe engine, according to Intel, will be a serious bump up from the current Gen 11 GPUs.

How many cores, and how fast? Breaking 5GHz by any margin is technically difficult for all sorts of reasons. The future is integrated multi-core, and efficient design. Sunny Cove managed an IPC (instructions per cycle) jump of approximately 15 to 18 percent over Skylake. Willow Cove squeezed 5-10 percent on top of that. This gives Rocket Lake the potential to make a healthy 20 percent or more IPC improvement at current clocks. As for cores, using the LGA-1200 socket points to a ten core maximum, although all the material we've seen says it'll be eight core. Perhaps Intel is keeping something in reserve. Overall Rocket Lake looks to be a major upgrade across the board, not the step-changes we've been used to recently. There are engineering samples floating about, and a few benchmarks, but at this stage no figure can be reliable. Rocket Lake is due for release next year, probably.

After Rocket Lake we have Alder Lake. There are no solid facts but plenty of idle speculation. It is expected to be a "big-little" design: a hybrid like Lakefield. It (may) have eight high-power Willow or Golden Cove cores, and eight smaller Tremont or Gracemont cores (Atom chips). These will sit along with the Xe graphics and ancillary chips in one package. One rumor has it that this will be launching this year, but that just can't be right. It's much further away than that. We've been used to chiding Intel for falling behind. If Rocket Lake does what we think it will, then Intel will be back with something of a bang. Good. **–CL**

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POPULAR, BUT FLAWED

Security and privacy prove problematic

VIDEO CONFERENCING is in high demand at the moment. Zoom is free with its basic plan, which helps explain its surge in popularity; traffic jumped over 500 percent in a month. Unfortunately, it's had more than a few problems too. It's supposed to have end-to-end encryption, but it didn't, it can't. It was also caught sharing data with Facebook. The iOS version passed a myriad of details over to Facebook (whether you have an account or not) when you logged on, despite having nothing about this in its privacy statement. It also had a tool that enabled your LinkedIn profiles to be collected. If you had LinkedIn Sales Navigator enabled when you ran a meeting all the participants' profiles appeared.

Zoom's lax security has also lead to half a million stolen accounts floating around the dark web. Its naming conventions have left recordings on cloud servers vulnerable. Simple numbered URLs also lead to "zoom-bombing"—unwanted, and often unfriendly, additions to your conference call. Zoom's problems are many—it simply wasn't ready for the huge number of new, non-business users.

New York's attorney general has written a warning letter, and a Class Action lawsuit has started in California. Senators are taking an interest, particularly in the way it handles underage users. It has been asked to provide information on its data practices and security history to government representatives. COVID-19 has shown how important video conferencing is, and that inevitably means tighter regulations.

Zoom has frozen development work while it fixes the security "issues", and LinkedIn and Facebook connections have been cut. The data sharing shouldn't surprise anyone: when something is free, it really isn't: the target is your data. **–CL**

CHINA HAS ITS OWN X86 CHIP

COUNTRY AIMS AT SELF-SUFFICIENCY

CHINA HAS PRODUCED its own modern x86 processor. The Zhaoxin KX-6000 series is a mainstream PC chip. It has PCIe 3.0, DDR4 support, integrated graphics, and suchlike. The top model, the KaiXian KX-U6780A, has eight cores, uses a 16nm process, and a base clock of 2.7GHz. There's no boost clock, multi-threading, or L3 cache. However, it's twice as fast as the previous KX-5000 series. It isn't quick, about on par with a Pentium G5600 in Cinebench R20. The graphics are particularly slow, dropping into AMD A10 territory. Essentially it's about eight years behind the curve.

China has an aggressive target to be self-sufficient in silicon (its 3-5-2 initiative plans to remove all foreign hardware and software in government offices by 2022). A truly competitive x86 chip is a way away, but the low-end of the market is within reach. **–CL**

WARNING: CONTAINS LOOT BOXES

Now included in the game rating system

THE ESRB, Entertainment Software Ratings Board, is not a fan of the Loot Box, which it likens to a form of gambling. It has now decided to tell you right next to the other warnings on violence, and language. It already flags in-game purchases, which it added after the fuss over *Star Wars: Battlefront 2*. This warning is to be expanded to include the line "includes random items." A game only earns the sticker if you have to part with money for an unknown reward. The ESRB has highlighted it as a particular concern for children, who can rack-up alarming bills.

Micro-transactions in games have earned game publishers billions. Top-tier games are expensive to produce, but it is increasingly difficult to charge a decent amount in a world of free-to-play titles and streaming subscriptions. Loot boxes are an easy fix, but lazy, and a touch predatory. However, it seems they, or something similar, are here to stay. **–CL**

Tech Triumphs and Tragedies

A monthly snapshot of what's good and bad in tech

TRIUMPHS

ZEN 3 THIS YEAR
Rumor has it that AMD is getting ready to launch its Zen 3 desktop CPUs later this year, probably this fall, with an enhanced 7nm node.

MICROSOFT EDGES AHEAD
Basing the new version around Chromium appears to have done the trick, partially—it now has a larger user base than Firefox.

CULT CARDS
The GeForce RTX 2080Ti Cyberpunk 2077 edition is rare, and valuable—it can fetch $5,000.

TRAGEDIES

A CHEAT TOO FAR
Vanguard introduced an anti-cheat kernel driver for Valorant, which has security experts spinning—your system is free for it to inspect.

BRICKED MACS
A Catalina update (10.15.4) has caused a rash of completely dead MacBooks. Halfway through they can just die completely—ouch.

WHERE IS FOXCONN?
After taking $4.5 billion in tax credits to build a factory, it's still largely an empty shell.

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Zak Storey

TECH TALK

Why Liquid Cooling Actually Sucks

MAN, THIS CERTAINLY FEELS WEIRD. First up, let me just apologize by saying I know, I'm not Jarred. And yes, I do have plenty of columns in this magazine this issue already. Don't worry, this isn't just me going on some sort of egotistical power trip now I'm the big cheese.

I'm going to be honest with you all. Sadly, due to budget cuts across all of Future's brands, Future's staff are under a lot of pressure to produce more content than ever for their own teams. With Jarred now working for *Tom's Hardware*, and ourselves being short of freelance budget, we sadly can't afford to pay him, nor does he have the time to write Tech Talk for us for the next two issues. He will return though—I have to stress this is not permanent. Like the sequel to Arnie's favorite cyborg movie, after these hard months are over *Maximum PC* will be back, fully staffed and ready to kick ass once more, and Jarred's insight and technological brilliance will be back on these humble pages. But don't worry, he's safe, secure, and so are his family, so that's one good takeaway.

Now that's out of the way, let's have a chat about that prodigal son of the custom PC world. Yep, I'm talking about liquid cooling. In particular, why it sucks. I know that's going to sound ridiculous, especially given how in-depth our feature on it was last issue, but man is it frustrating at times.

Over the last five years, I've had the pleasure of building somewhere close to 60 separate PCs. 12 of those have come with varying forms of liquid cooling, not including AIO builds. So I've toyed with everything in this niche hobby of a hobby. Alas, this gives me some serious perspective as to why liquid-cooling sucks. So let's break it down.

1. THE COST. First and foremost, the biggest hurdle any would-be liquid cooler has to get past is the expense. The problem is, if you're committed to your liquid-cooling aspirations (because let's face it, it looks cool, and for most of us that'll be 70 percent of the reason to do it), you're going to start by stripping down something like an $800 flagship graphics card, and strapping a $124 water block on.

2. THE FITTINGS. Oh boy, where do I even begin with this one? For any first-time liquid cooler, when it comes to these tiny, pricey parts, you'd plan your rig, go "OK, I'll use soft tubing first as that's the easiest," and then say to yourself, "All I need is some compression fittings to get the job done." Although technically this is possible, building a rig with just soft tubing and standard compression fittings is not the easiest way.

And here's the thing; the more liquid-cooled rigs you build, the more experience you gain, and the more likely you are to lean into using an ever-increasing arsenal of fittings. Which in turn jacks up the price.

To give you an example, the 4K gaming monster build we did back at the end of 2019 featured a total of 70 fittings, of 12 different types and two different brands, totalling $525.31. That is an insane figure, but couple that with the average water block costing well above the $100 mark, radiators being close to $80–$100 each, and pumps and reservoirs commanding equally as much, and you can easily end up with a loop cost bracing itself at near $1,700.

3. THE KNOWLEDGE. And then we have the painful learning process involved with this whole thing, so much of which is trial and error, researching, and planning, and it's just endless. Here are some basic guidelines: First, always ensure that your pump is gravity-fed by a reservoir. Second, never mix your metals in a loop, and if you can afford it, always use copper. Third, when filling your loop, always ensure that all of your components remain unpowered, except your pump, and never let it run dry. Fourth, always try to flush your blocks and radiators before you build your loop to get rid of any excess flux. Fifth, always test that your components work before commencing your build. Sixth, always double-check you've either plugged or connected tubing to every available G1/4 port. Seventh, always triple-check that your compression fittings are tight enough on your tubes, and that your tubes are seated correctly. Eighth, never forget a rubber o-ring.

4. BENDING TUBES. After that's all out of the way, you've then got tube bending, which is a mystical art in itself, and honestly I question how it works every single time I do it. And every time when I produce my first bend, I can guarantee you it still feels like I'm doing it for the very first time.

When it comes to tubing, you have to consider whether its PETG, or normal acrylic you're bending (PETG has a lower bending point and different heating characteristics, and is shatter resistant, but it's slightly less transparent and has a habit of color-leeching a little sooner). You

then have to plan where the bend is going to be in the length of tubing, the angle you want to achieve, and what you're going to use as your angle guide. In all honesty, most folk, myself included, will recommend that you stick to lengths of tubing with a single 90-degree bend in it. Any more than that and the tubing run starts to look messy and nowhere near as sharp as how you pictured it in your head—at least until you're a pro.

That said, if you are after additional angles, there are a ton of good bending kits available (here's looking at you Alphacool). But honestly after a while you'll just end up using the corners of tables, or anything square. In my case, rather ironically, I use the corner of a bending kit pelican case to achieve my 90-degree angles, failing that you'll just end up eyeballing it.

That said, with all the best will in the world, you can watch numerous videos and tutorials on how to bend tubing, but the best way of learning how to do it is by doing it yourself.

5. THE PERFORMANCE GAINS. This is going to hurt me to say this, but honestly, the performance gains are not as grand as we all like to think. Yeah, you will get lower temperatures, but the majority of the time your components are just going to be limited by their architectures and your draw in the silicon lottery. If you're big into overclocking it certainly helps, but it's not enough to overcome major stability hurdles. In fact, at most you're going to be looking at perhaps a 10-15 percent performance increase versus traditional AIOs or air cooling, and that's being generous.

The biggest advantage is with auto-overclocking features such as that found on Ryzen, with Precision Boost Overdrive in particular (especially if the VRMs are cooled too), and with GPU Boost for graphics cards.

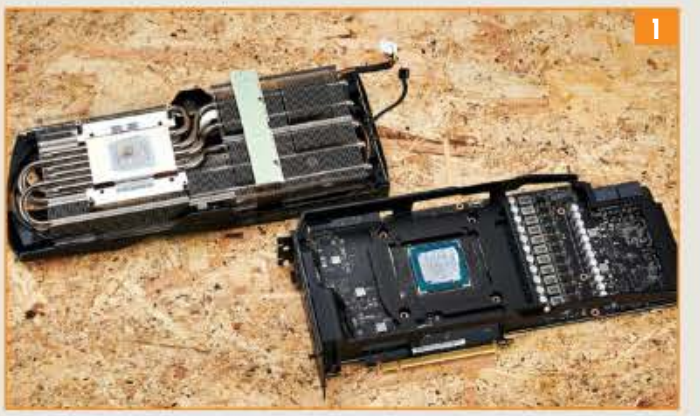
The best thing about liquid cooling is the reduction in overall noise that's achievable. Strap two massive 360mm radiators into a loop with a single GPU and CPU, and you can immediately run those six fans far quieter than if those components were cooled traditionally via attached air coolers and heatpipes.

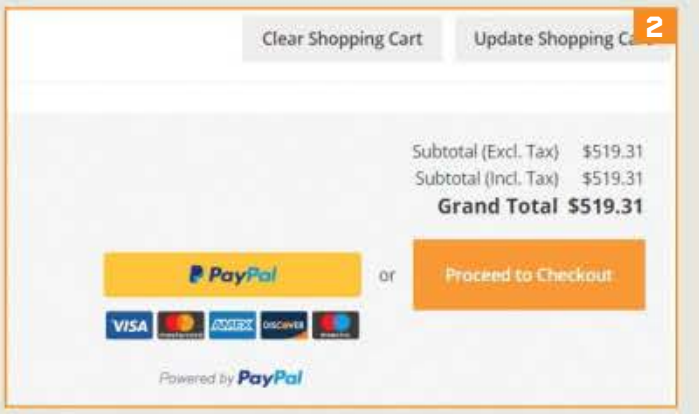
6. THE MAINTENANCE. So you've got your system up and running, it's fully liquid-cooled, looks baller, temperatures are lower and performance is slightly higher, now you've got to maintain it. In the first week that means your first challenge is going to be getting rid of any trapped air throughout the system. To do this, you can wait, or you can tilt and shift and shuffle the case around in what seems like the world's biggest puzzle, in an attempt to get the air bubbles up to the reservoir, before topping it off with a bit more coolant. Once that's done, congratulations! Your system is running as intended.

However, over time, without proper maintenance, coolant can gunk up water blocks and stop them from functioning as efficiently, reducing thermal performance in the process. That means every 6-12 months (sometimes longer if you've got the right coolant) you'll have to drain the entire thing, strip it all down, remove and flush the radiators and the waterblocks, put it back together again, and refill it.

7. THE REALITY. So the reality is that it costs an absolute bomb per loop to create, takes an age to learn how to do properly, requires some serious thinking and planning before you even look at buying parts, and the performance gains outside of noise reduction are few and far between. Add in the additional anxiety that comes with stripping down stupidly expensive components (thanks Nvidia), building your own loop, and having to maintain it all, and it just really doesn't make any logical sense to the average user.

Yet here I am, 12 liquid-cooled systems in, still building them, still learning from every attempt, and it's likely I'll continue to do so unless I lose the passion for this woeful hobby of ours. Why? Well, aside from my delicate Millennial ears preferring my PC to make somewhat less noise than a jet engine at take-off, the reality is that builds like these just look so damn cool. They're a halo product among halo products, the true pinnacle of what you can achieve, and if you can look past the long list of frustrations, the eye-watering expenses, and the time it takes to create these short-lived performance kings, as our industry moves ever upwards in core count and clock speed, there's just something unequivocally beautiful about the results of probably one of the most frustrating hobbies that's in existence.





> You'll have to drain the entire thing, strip it all down, remove and flush the radiators and the waterblocks, put it back together again, and refill it.

Zak Storey has been a PC enthusiast and system builder for nearly 2/3rds of his life.

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THE LIST

INDIE GAMES YOU SHOULD BE PLAYING

TACOMA

An abandoned spaceship and a rogue AI are the backdrop for a gripping puzzle game, where you manipulate 3D security footage to glean information from your surroundings.

INTO THE BREACH Sadly underappreciated, despite its blend of sci-fi puzzling and turn-based strategy.

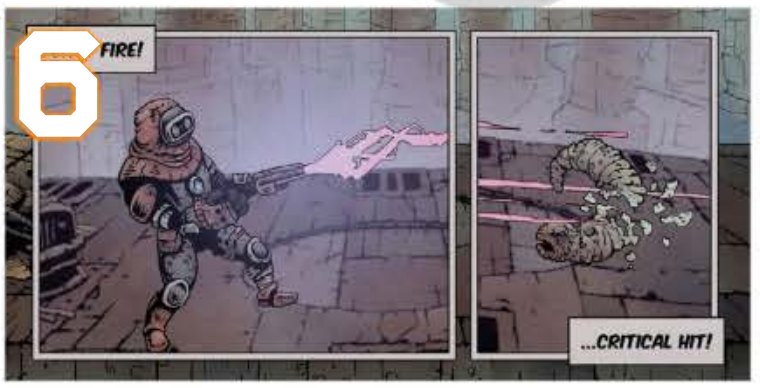
7

WHAT THE GOLF?

It's golf, but not as you know it. Launch everything from houses to hot dogs with your trusty 9 iron in this surreal and hilarious sports sim.

JØTUN

Gorgeous hand-drawn boss fights punctuate this jaunt through Scandinavian mythology, as you play a betrayed Viking warrior fighting to prove her worth to the gods.



DEEP SKY DERELICTS A bleak dungeon crawl through the empty husks of ancient spaceships.

GRIFTLANDS This is a sci-fi roguelike with deck-building and narrative decision-making elements.

APE OUT Take control of a painted gorilla and bust out of zoos, prisons and research labs, all to pumping jazz.

FURI A frenetic boss rush, swapping between close-quarters combat and chaotic bullet-hell sequences.

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HEAD TO

BY **CHRISTIAN GUYTON**

Mini Cases vs Mid Cases vs Full-Tower Cases

Case size—it's an interesting question. Should you go for a mini tower, with its ITX motherboard and compact design? Or the full tower, with room for numerous components and cooling solutions, ideal for a super-powerful build? Or is the best option the humble mid tower case; the modern standard? We're going to break down the advantages and disadvantages of each type of case, and—hopefully!—decide which size is best.

ROUND 1

Value

You might assume, if you're not well-versed in the pricing of PC cases, that mini tower cases would be the cheapest option. That's not always the case, though, as compact chassis tend to have additional design aspects that make for more efficient use of space, and these drive the price up. Fractal Design's Node 202 media center case includes a right-angled PCIe riser for vertical GPU mounting—it's necessary in such a flat case but is also an extra item to add to the price. That said, it's also easy to find mid-tower cases with pricey add-ons.

Full-tower chassis, unsurpsingly, are the most expensive. We went hunting for the cheapest case of each type that we would actually recommend (no super-cheap knock-off brands here) and while good mini and mid-tower cases both went as low as the $50 mark, we'd have to spend almost $150 to get a decent full-tower chassis.

Most of the big names in cases—Corsair, Fractal Design, Cooler Master to name a few—have a wide range of cases available, large to small, pricey to affordable. The usual missing combination here is budget full-tower cases; typically, if you've got the cash for a big, powerful system build, you can afford to splash out on your case.

Winner: Mid Tower

ROUND 2

Flexibility

This was an interesting category to interpret. Should we award it to full-tower cases, with their ability to fit any size of motherboard and cooler? Or does the prize go to mid towers, the middle-of-the-road choice, the jack-of-all-trades? Let us explain our logic.

For flexibility, we considered what different roles a system built inside each case could fulfill. As such, we eliminated full towers from this round, on the basis that a full-tower PC can only really function as a big, powerful desktop system; perhaps a dual-motherboard rendering or streaming rig. Using a full tower as a home NAS system is farcical, unless your family somehow has enough data to fill 20 hard drives.

A mid tower can be more or less anything; gaming PC, editing machine, media center. However, the win goes to mini towers. Anything a mid tower can do, a mini tower can do—only in a smaller and more portable way. A compact form is a very desirable feature for media center and home-cloud servers, able to unobtrusively occupy space under the TV or in the cupboard. Advancements in modern CPUs and GPUs mean that tiny systems can be rendering powerhouses now too, perfectly capable of keeping up with their mid-tower cousins.

Winner: Mini Tower

ROUND 3

Build Difficulty

Ask any member of the *Maximum PC* crew about the worst case they've ever built in; chances are, the culprit will be a mini-ITX offering. Limited space to work in, component incompatibility thanks to inadequate headroom, and arcane cable-routing solutions often lead to frustration when building inside a mini tower. While they are at least usually lightweight and easy to move around while building, the cramped interiors mean that the builds prove much trickier than expected.

Full-tower cases, of course, have the exact opposite problem. You'll always have enough room to get both hands (and in some cases, both forearms) inside the case to work, but the bulkier form factor means that moving the case around during builds is a hassle. Full-tower cases routinely weigh upwards of 30 pounds, too,

What brings us a sigh of relief is seeing a Build It plan that uses a mid-tower case. The mid tower would never slice open our fingers as we struggled to squeeze a screwdriver inside it. The mid tower would never slip out of our hands and land directly on our big toe. The mid tower is safe; it's familiar, even comforting. And thus, we have our winner here.

Winner: Mid Tower

HEAD

From left to right: **Slender mini-tower cases can make for excellent home media centers. Mid tower can still look super slick, as Phanteks proves with this model. Full-tower cases can get pretty weighty, like the 65-pound Obsidian 1000D from Corsair.**

ROUND 4

Features

As we mentioned earlier, mini-tower cases have plenty of potential for nifty additions. We've seen everything from giant solo fans to removable I/Os, and yet the teeny-tiny cases are still the ones that manage to innovate. Yes, a full tower can fit 10 RGB case fans at the front, but most systems don't need that; space-saving solutions for a powerful but compact system are far more valuable.

Larger cases do tend to have larger I/Os with more ports, but again it becomes a point of quantity over innovation; four USB ports on the front of your system is nice, but is that better than two USB-Cs? And, do you really need a front I/O with four USB-A ports?

Really, any case can have cool and useful features beyond the baseline, most of which will usually make the case more expensive. If you browse for cases upwards of $100, chances are it'll have some fancy unique selling point to persuade you to buy it. One of these pops up more often than others, though; various iterations of the carry handle, sometimes seen atop mini-tower cases. A handle might seem simplistic, but it's a feature that can totally change a system's purpose, instantly making it easily portable, and for that reason we'll give the win to mini towers.

Winner: Mini Tower

ROUND 5

Aesthetics

Again, this is a tricky one to judge, mainly because the question of aesthetics often comes down to a subjective opinion rather than objective fact. Even in the *Maximum PC* office, debates as to whether a new case is ugly or beautiful are as frequent as they are fierce. What constitutes a good-looking case? Some would argue that it's a full cohort of synchronized RGB lighting, while others might say that sharp, defined angles and colors make for the best visual design.

Whatever your opinion, we think it's fair to say that mini towers might lose out this round. It's still a matter of personal preference—we're sure many of our readers (and this mag's Editor) love the look of mini-ITX cases—but the compact design simply means that there's less space for the manufacturers to show off their aesthetic chops. Many small cases opt for a simplistic design, to favor portability or to better blend into a room.

In fact, upon browsing through some online storefronts, the majority of mini-ITX cases are just nondescript metal boxes, with only a handful even offering something as basic as a windowed side panel. Both mid and full-tower cases often feature tempered glass windows to show off the inside of the build, so we're going to declare this round a tie.

Winner: Mid & Full Tower

And the Winner Is...

Yes, the best kind of computer case is the mid tower! Really, if you're building a desktop system for regular work or gaming, the mid tower is frequently the best option. It's the working man's case; adaptable, affordable, and typically straightforward to build in. They're the perfect cases for inexperienced system builders, too; if you're new to the game, or want to help a friend assemble their first PC, mid tower is the way to go.

With that in mind, though, it's important not to underestimate the worth of mini and full-tower cases. Ultimately, the best case for the job is the one that best suits the purpose of your builds; if you want a dinky LAN gaming system to take to your buddy's house, you'd best find yourself a mini-tower case with a carry handle. Conversely, if you're committing to streaming and want a dual-system setup, a beefy full tower like Corsair's Obsidian 1000D will suit you best.

The best type of case is simply your favorite type of case. No matter what size or what you use it for, as long as you like your case then it's a good case. (Mid towers still win, though.)

DOCTOR

THIS MONTH THE DOCTOR TACKLES...

> Permission issues
> SSHD pen letter
> USB port problem

Game folder permission problems

I have a new ASUS TUF gaming laptop. I copied a game folder from my desktop PC to a thumb drive, then to my laptop to keep the saved files in sync when I traveled. When I got back, I tried to copy the files back to the thumb drive but got the error, "Your organization does not allow you to place this file here." I discovered it's the folders rather than the files that won't copy; I was able to create the folder and subfolders on the thumb drive then copy the files in the folder and subfolders, a slow chore. I've searched the Internet for solutions, but, no solution. Where are these permissions in Windows? How do we turn them off?

–Thomas

Manually copying game-save folders can cause problems.

THE DOCTOR RESPONDS: This sounds like the game folder you copied was housed in a protected folder that is owned by a system user (such as TrustedInstaller) rather than your own user account. This error message occurs most frequently in conjunction with the hidden WindowsApps folder where programs installed through the Microsoft Store reside, but if you installed the game through other means, it's possible that the installer set permissions in such a way as to prohibit (or at least discourage) folk from copying the game.

Sadly, without knowing what the game is, what was in the folder you were copying, and where you installed it from, the Doc can't offer specific advice in this instance, but he's certainly not going to recommend messing about with permissions without knowing more, as you could quite easily trash your enitre Windows installation.

What the Doc would suggest is that you install the game separately through the usual channels on both laptop and desktop, then look for an alternative means of backing up and transferring game-save data between them—for example, GameSave Manager (www.gamesave-manager.com) supports over 6,800 games. Just download it, extract it to your USB drive, and then run it directly from there to transfer your saved games between machines.

Unwanted temp files piling up

Hello—for months now there has been junk files in the %temp% folder with the name mat-debug-xxxxx.log—where the numeric part seems to be the PID of the process that created it. These files are zero bytes, but in some cases I found over a dozen of them, and a new one seems to be created every 10-15 minutes or so.

They seem to reproduce like rabbits. There have been numerous posts in the Microsoft forums, with all sorts of ways to stop this, but for me none worked—has the Doctor found a way to stop these files from being created? **–Frank Esposito**

THE DOCTOR RESPONDS: These files have only started appearing relatively recently—possibly since the last major Windows update (1909). There are several theories for where they come from—some claim they're linked with graphics drivers, others point towards Office telemetry. From what the Doc can gather, there is no definitive information out there as to what these files are, but they're a cause for irritation rather than genuine concern.

Given the Temp folder is always full of files you'd normally ignore in day-to-day use, the key here is to manage things so that it doesn't fill up to clog up your entire drive. Thankfully, the folder—among other temporary files—can be kept in check using Storage Sense: head over to "Settings → System → Storage," flick the switch to on and then click "Configure Storage Sense or run it now." Choose how often

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↘ submit your questions to: doctor@maximumpc.com

it should run, and make sure the "Delete temporary files that my apps aren't using" box is checked. If need be, you can scroll down and click "Clean now" to perform a quick cleanup, which will delete all files in the Temp folder that are older than a week.

Where's the love for SSHD?

Your magazine has nearly become a solitary blueprint for my hobbyist build ideas, and I found myself wondering the other day why SSHDs aren't more talked about in general. I have used them in a few super-budget builds lately, and they seem to show promise for the cost. Would you consider doing a product comparison with SSD vs SSHD vs HDD? Or, perhaps a head-to-head comparison of the top SSHDs and an SSD control subject? I'm curious to know your thoughts from a cost/benefit perspective. Even a piece on how they work would be interesting. Thanks for the endless info, tips, and tricks!

–Shannon Benikosky

THE DOCTOR RESPONDS: Solid State Hybrid Drives represent a snapshot in time when the price of SSD storage was still prohibitively high. As the name implies, they combine a regular spinning-platter drive with a small amount of SSD storage (typically 8GB, although some models support 32GB). The drive then identifies the most frequently accessed files on the drive, placing them on the SSD portion to speed up access.

While SSD drives were relatively expensive, SSHDs offered a smart compromise between capacity and performance. They're obviously not as quick as full-blown SSDs because most files remain on the slower portion of the drive, but they're a vast improvement over regular hard drives when it comes to boot and application load times.

When it comes to cost, a direct comparison between SSHD and SSD appears to confirm that SSHDs still hold a significant advantage: you'll pay $80 for a 2.5-inch 2TB SSHD, and $100 for the 3.5-inch model—less than half the price of a 2TB SSD. That seems like a no-brainer for those on tight budgets, but consider this: you can buy a 120GB SSD for under $25, and a 2TB regular hard drive for around $50. So, for less than the price of a single 2TB hybrid, you can have a fast 120GB boot drive and 2TB drive for storing files, while keeping data separate from Windows and apps.

Replacing busted USB ports isn't expensive.

SSHDs may no longer hold the same appeal from a price perspective, but they do still possess one major advantage: they're perfect for when you only have space for a single drive, and need both performance and capacity—typically in laptops.

Sadly, the Doc sees no future for SSHDs, as SSD prices continue to tumble—if the onboard SSD storage was 64GB there might be a stronger case for them, but 8GB looks to be the norm, so they are less compelling, even for those on a budget.

USB 3.0 port problem

My old Win7 x64 desktop, GA-H61MA-D3V (rev. 2.0) mobo + Intel Core i5 3550 has two rear USB 3.0 ports, and they have not worked for a few years. Peripherals plugged into them light up, but there is no Windows recognition. Device Manager has no errors, but should I be suspicious that there's no reference to USB 3.0 under "USB controllers"? I've installed the latest BIOS and drivers from Gigabyte, including the Etron USB 3.0 drivers. Can USB ports go bad?

–Curtis Raff

THE DOCTOR RESPONDS: Your mobo's Etron EJ168 USB 3.0 host controller has been plagued with problems over its lifetime, but the lack of any reference to an "Etron USB 3.0 eXtensible Host controller" in Device Manager is very suspicious. Try reinstalling the Etron USB 3.0 drivers again—the latest version via Gigabyte is 1.0.0.118 from November 2013, which is the latest version available (see https://bit.ly/MPC178usb for an alternative download).

If this driver fails to install, boot into your BIOS setup utility, navigate to peripherals and verify "USB 3.0 Support (Etron EJ168 USB Controller)" is enabled—if it's not, switching this on should bring things back. We suspect it's already enabled, so your next step is to see if you can get the ports recognized in Linux. Create a live Linux CD using a distro running Kernel 5.2 or later (Ubuntu 20.04 LTS or 18.04.4 LTS both meet this requirement), and run it in "Try" mode. Connect a USB storage device to one of the USB 3.0 ports, and it should show up in the"Files" tool.

If nothing shows up in Linux, then it's safe to write off the ports. Thankfully, your mobo has three PCI-Ex1 slots, so you could purchase a USB 3.0 PCI-E plugin card like the Rosewill RC-508 4-port USB 3.0 card ($23.99, www.newegg.com) to restore USB 3.0 support to your PC.

Can't switch HP function key lock

I purchased an HP Pavilion All-in-One 24-xa0119, which is swell but for one very annoying issue: it comes with a sleek keyboard that has the multimedia functions on the function keys, forcing me to hold Fn to use them as actual function keys. Every other keyboard I've used has done the opposite—I regularly use Photoshop, and I have actions that I run using the Function keys for repetitive tasks. I don't wish to use fn+F2 to run my crop action, nor do I want to buy another keyboard.

Older HPs let you change the setting in the BIOS, but this is not present here. As an HP employee on their forums said, "I must let you know that this isn't an issue, it's by design, Function key settings are only available for laptops, the default function for all-in-one devices cannot be changed." Without getting into the stupidity of this decision, is there any way to override this design choice? A script of some sort that auto-runs with Windows, or some registry tweak? None of the combos I have read online (fn+Esc, fn+Caps lock, fn+Shift) turn fn lock on. There is no fn lock key or indicator on the keyboard.

—Brian Di Cesare

THE DOCTOR RESPONDS: The HP forums are littered with irate users such as yourself, Brian, and for good reason. What possessed HP to remove any option—within Windows or in the BIOS—to allow you to switch the order back to what most people consider logical is beyond the Doc. The problem isn't limited to all-in-one users either; HP sells the offending keyboard (a Pavilion 600 wireless model) standalone too.

You could try a few more combos—fn+Ctrl+Alt, or fn+Ctrl+Shift, or even Fn+Win—but we suspect you're stuck with the keyboard's foibles. If that's a deal-breaker, you'll find plenty of sleek, wireless (and unbranded) keyboards on Ebay that behave properly and won't look out of place next to your all-in-one PC. They're relatively cheap too. That said, HP should perhaps offer some kind of exchange program for those who find the keyboard's foibles too much.

BUILDER'S MANUAL

Whether you're new to PC building or a veteran, we can all learn something

By Christian Guyton

(00) If you're reading this magazine, you probably know a thing or two about computers, or at least want to learn something. When it comes to building your own PC, there are numerous pitfalls to avoid and tricks to bear in mind. You need the right tools, the right knowledge, and the right level of emotional resilience to keep on trying when something inevitably goes wrong.

Building your own computer won't necessarily be cheaper and will definitely be harder than buying a complete system, but it affords you more control over the capabilities of your hardware. There are numerous issues to contend with when setting out to build a PC, even if you're a seasoned hardware guru, so with that in mind, here's some of our best advice.

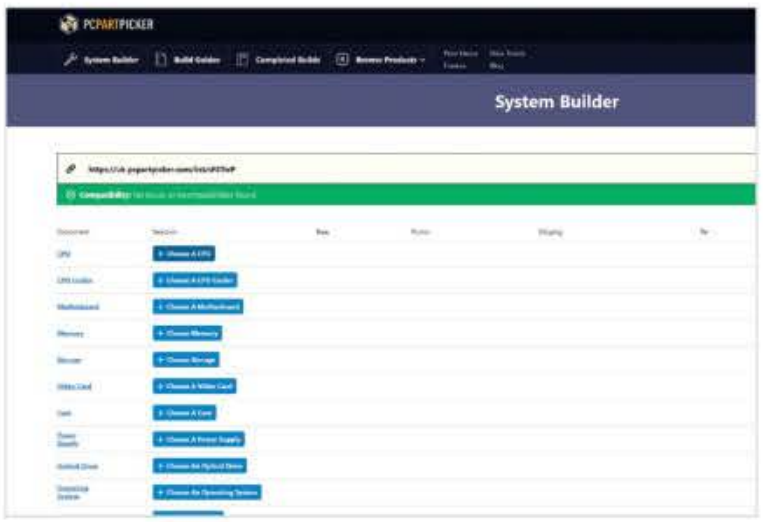
(01) Plan Your Build

The first thing you should think about is what you actually want your build to do. Is it a beefy 4K gaming machine? A video-editing platform? A plain old work PC? Whatever the reason, it's important to nail down the build's purpose first. This will determine just about every aspect of the finished build, from your choice of processor to what OS you're going to install. Consider where the PC will sit—on your desk at work, or underneath your TV in your living room? If there are any key components you want to include—such as a specific case, or a GPU that is ideal for your chosen purpose—work that out sooner rather than later. Be sure to do a little research on alternatives, though.

(02) Acquire Knowledge

Do your research! There is a wealth of information strewn across the Internet, from tutorials to reviews—and there's plenty of that in the magazine you're reading right now, too. Reviews are an extremely useful source of knowledge when it comes to choosing which parts you're going to use—flip forward a few pages, and you'll find some great ones. Manufacturers' websites are also worth a look; most have PDFs, manuals, and specification lists that can prove invaluable when it comes to actually building and setting up your new rig.

AMD
AMD
X479 AORUS ULTRA GAMING
GIGABYTE
AMP-UP
PHANTEKS



(03) Make a Part List

Once you've got some ideas about what you want your finished build to look like, it's time to get organized and list the components you want to use. A trip to http://pcpartpicker.com (pictured above) will do you good here; not only can you easily tally up your budget and keep a running list of components you want to use, but the website flags up any compatibility issues that you might not otherwise notice. Consider your budget carefully at this stage—it's all too easy to drop too much on your GPU and not leave enough for a decent power supply. Unless you're in a major rush, it's usually worth waiting until components are on sale—you should be able to chop off a comfortable 10 or 20 percent from the final price with a little patience. And remember: RGB lighting might look nice, but put performance first.

(04) Strip It Down

We always recommend starting any build by stripping your case down to the bare essentials: Remove any side panels, dust shields, and windows. If you're not using the hard drive cages or additional brackets, remove them and don't put them back in; this helps to improve airflow by maximizing negative space inside the case, and leaves more room for cable management. Be careful when removing thumbscrews, particularly on glass panels. It's all too easy to leave an unappealing smudged fingerprint on your otherwise unblemished case.

(05) Part Storage

Don't throw away your boxes. The box your case came in, in particular, is useful both for storing panels during the build process and for holding the boxes of whatever components you're putting inside. If, like us, you're building PCs on a regular basis, this can be very helpful when it comes to keeping track of which component is in which case. In addition to good organization, keeping the boxes comes in handy should you need to make use of a warranty and get a part replaced. Particularly when working with cases that have a lot of glass, storing window panels between the polystyrene that comes in the box can prevent them from being scratched or smashed.

A stripped-down NZXT H400i microATX white mini tower case.

(06) Choice of Fan

To keep your case cool, choice of fan is vital. In broad terms, fans fall into one of two categories: bulky static pressure fans, and thin many-bladed airflow fans. The former are designed for high-pressure environments, such as moving air through a thick heatsink, while the latter variety moves more air quickly through the case, but with reduced force. Mounting multiple airflow fans inside your case ensures—as their name implies—good airflow, but static pressure fans are vital for radiators if you're using an all-in-one cooler. Some fans utilize magnetic bearings to "levitate" the fan, which provides less noise and longer lifespans, but they typically come at a greater cost.

Same fan, different blades. The thick blades are optimized for high pressure, while the thinner blades maximize airflow.

(07) Fan Management

Most cases come with one or more fans pre-installed. These are typically stock fans from the case manufacturer or one of its partners; when it comes to keeping your build cool, they do the job, but generally don't measure up to fans purchased from dedicated manufacturers. Whether you're looking

A pair of Silent Wings fans is included as part of the package when you buy the Silent Loop 240mm AIO.

for high-performance cooling or silent running, there are often better options available. If you're upgrading the case fans, do that before building. If there's still room, however, it's worth considering keeping the stock fans inside the case as well. Most stock fans can be installed in the front or back of the case they come in, so if you're replacing your rear fan with something flashier, it's a good option to push the stock fan to the front of the case to pump up the airflow.

(08) Cable Threading

With smaller or cheaper cases, which might not have as much space for tucking away your cables, installing your PSU early and threading through power and I/O cables before installing the motherboard can make your life a lot easier. Using cable ties is the way to go here, unless you've gone for a case that includes integrated cable management options, such as Velcro straps for securing cable bundles. Don't forget that you can feed smaller cables directly underneath the motherboard before installing it. Cheaper PSUs are likely to come with a bundle of cables you won't be using, so neatly pack these together with a cable tie, and store them out of sight—ideally underneath the PSU shroud, if your case has one.

(09) Right Direction

Fan orientation sounds simple, but it can be easy to get wrong. Most fans include small arrows on the plastic frame, indicating which direction the fan spins in, and which direction it pushes air in; alternatively, just check which side of the fan the power cable protrudes from. If you're mounting multiple fans on a single section—such as two fans either side of a heatsink tower, or stacked fans in the front of your case—make sure they're pumping air in the same direction for maximum efficiency.

(10) Speed Control

Fan speed is an interesting topic; higher RPMs (revolutions per minute) are obviously going to increase airflow, but also produce more noise. Smaller fans demand a higher RPM to work effectively, so don't go

(11) BUILD IT YOURSELF?

In broad terms, building your own PC will bleed your wallet less than buying a pre-built system, but this isn't always the case. If you're patient, waiting to snap up decent parts on sale, you can always assemble a powerful computer on a sensible budget, but pre-built models do have their advantages: Tidy internals and manufacturer-assured assembly mean that issues such as overheating and component incompatibility are seldom a problem. It can also be a relief to have that manufacturer warranty to fall back on. Some even come with lifetime coverage.

A pre-built system lacks a few things against custom builds: They're not bespoke, and many are needlessly tricky or even impossible to upgrade. If you're looking for the ideal purpose-built PC, you're better off taking the leap and assembling it yourself. Bulk-purchasing components means that pre-built systems can contain high-end parts at a relatively low premium, and there's a certain degree of assurance that the chosen parts will function optimally together. Many come with unique cases that can't be purchased standalone. These are often extremely nice to look at, but a challenge to actually work in should you want to fiddle around with your rig's guts.

Pre-built systems have come far in the past few years. Current offerings from companies such as Digital Storm, Origin PC, and Corsair are powerful and effective, although they will result in a heftier price point. Higher-end pre-builds are generally a better option—if you're assembling a PC on a tight budget, DIY is often the way to go. Ever evolving standards mean that prices are always in flux, and trying to build your own computer from scratch can be a potential minefield of bad prices. There's also the funny middle ground occupied by groups such as Xidax, who will build a custom PC on your behalf—for an additional fee.

Pre-built systems can have some very elegant cases that are otherwise out of reach.

© HTTP://PCPARTPICKER.COM

(12) TO RGB OR NOT TO RGB?

RGB lighting is a topic of much debate both at the *Maximum PC* office and on every single computer hardware forum in existence. There's no denying that filling your build to the brim with LEDs can result in a computer that looks like a cross between a sports car and the most expensive *Star Trek* prop ever, but "expensive" is often the operative word there. It's tempting, too. RGB coolers and fans are becoming more prevalent, so it's easy to be drawn in. Those little additions often add up, though.

A pair of premium maglev case fans from Corsair will run to around 30 dollars, while their RGB counterparts cost easily that much for a single fan. Stick-on LED strips aren't too expensive, but can require expansion kits and RGB controllers that drive up the price. And, of course, you need a case that shows off your multicolored lights—that means tempered glass or even RGB-focused cases, which could result in a less than sensible total cost. At the very least, control software for most branded RGB gear is free to download.

A good rule of thumb when it comes to RGB is to simply ask if you could get the same performance for a cheaper price without the lighting. If you're going to spend an extra 50 dollars on a case just because of its glass front, consider how much time you're going to spend looking at your PC against how much time you're going to spend looking at the screen. Putting that money toward a superior monitor is always going to serve you better, especially if you're operating on a budget. But if you've got the money to burn, or you come across an RGB piece that outperforms one without, go right ahead and turn on the rainbow.

with anything smaller than 120mm for your case unless the circumstances demand it. Some cases come with an integrated fan control unit, which enables you to adjust fan speeds on the fly—just make sure you're not leaving them on the lowest setting when gaming in 4K.

(13) Processor Cooling

Case fans are great, but CPU cooling is crucial in keeping your rig running under stress. There are three options: a traditional air cooler, full liquid cooling, or an all-in-one (AIO) cooler unit that uses both fans and liquid coolant. The first is typically what comes in the box with your processor—these stock coolers are decent enough, and generally not too hard to install, but don't provide high-level cooling. Complete liquid-cooling loops are tricky to install and cost significantly more, though their performance is often unparalleled. AIO coolers are frequently the best option, providing top-notch cooling with a large degree of flexibility, and little to no maintenance. If you're overclocking your CPU, a good AIO cooler is heartily recommended.

The fan controller has been developed to analyze the noise in the chassis and adjust the fan curves.

(14) Air Pressure

There are two possible options for maintaining good air pressure inside your build. Balanced air pressure means the case draws in a similar amount of air to how much it pumps out, keeping airflow steady, and temperatures lower. Positive air pressure means your build draws in more air than it pumps out—this can prevent air entering through unfiltered sections of the case, potentially reducing dust build-up. The difference in temperature is relatively minimal, but if you're serious about cooling, balanced air pressure is generally better—test both out using stress-testing benchmarking tools such as Prime95 if you're curious about the results. There is a third option—negative air pressure, the (surprise) opposite of positive pressure—but you want to avoid this, as it tends to result in build-up of dust inside your case.

Keeping your processor cool when under load is essential, and there are several options you can consider.

(15) CPU Installation

The core of what makes your PC tick, central processing units come from two primary manufacturers: AMD and Intel. AMD CPUs are a little easier to install; simply lift the retention arm, slot the CPU into place by lining up the gold triangle on one corner with the matching corner on the socket, then lower the arm back into place. All done! Intel CPUs are a smidge more complex, with the pins mounted on the motherboard rather than the processor chip, and a metal bracket that sits over the CPU socket. Lift the retention arm, then slide the bracket out from under the fixed Torx screw, and raise it to reveal the socket. Line up the CPU and place it in the socket, then lower the bracket and retention arm back into place. Intel motherboards come with a plastic cover over the CPU socket; this comes off automatically once the CPU is in locked in.

Grab Your Gear Clothes may make the man, but tools make the PC builder. Here are some of the most helpful items you'll come across.

(16) SCREW BOWL You can splurge on a magnetic bowl for your screws if you want, but really, any little bowl will do the trick. Even a simple kitchen ramekin will work. The important thing is keeping all of your screws in the same place when you're working on a rig; they can be easy to lose, and that only leads to frustration.

(17) THERMAL PASTE Most coolers come with paste, but our go-to is Noctua's NT-H1. It's not very expensive, and Noctua coolers come with some—one tube is good for multiple applications, and it's a pleasingly thick, non-conductive paste that does a good job of transferring heat. You only need a pea-sized dot on normal CPUs.

(18) CABLE TIES These are the most important thing for any PC builder. They're dirt cheap online, and come in a variety of sizes for different uses, primarily for organizing the internals of your rig. Most cases have slots on the frame to strap down cables, and they can be used for tying up loose wires to keep your case tidy.

(19) ISOPROPYL ALCOHOL If you're planning on switching out your processor or cooler, you're going to need this stuff. It's inexpensive, and nothing is more effective when it comes to cleaning off dried thermal paste or dirty smudges on metal. As an added bonus, it's one of the few substances that isn't going to kill your components if it gets on them. Keep it away from your eyes, though.

(20) SCREWDRIVERS A Phillips screwdriver will serve you well in most situations, but a proper set is worth the money. Allen screws, tiny M.2 drive screws, and bizarre proprietary screws all prove frustrating eventually, unless you've got the right tool to coerce them loose. If you've got a bit more cash, mag-tip screwdrivers can be a godsend when dealing with smaller screws inside a case.

(21) SPUDGER This funky little gadget will set you back barely a dollar or two, and can come in very handy. Used by the tech-dismantling pros at iFixit for prying apart stubborn components, its thin plastic edge can also be used to gently realign bent pins on AMD processors.

© CORSAIR.COM

AMD CPUs are easy to install: Just lift the retention arm, and slot the CPU into place, lining up the gold triangle.

When installing your GPU, remove the two PCIe blanking plates on the motherboard, before dropping the card into its slot.

(22) Memory Installation

RAM is one of the easiest things to install. Memory slots have either one or two clasps on their short edges, so ensure these are open first. Find the notch on the base of the memory stick, and line it up with the notch in the memory slot, then push it down. It should click into place—the clasps pop shut automatically. Bear in mind that memory slots are usually not in numbered order on the board; they are typically color-coded to indicate which slots use which channels. For dual or quad-channel support to work properly, the RAM needs to be installed in the correct slots. If you're unsure, check the motherboard's manual—it'll let you know exactly which slots to use.

(23) M.2 Installation

If you're using conventional HDDs or 2.5-inch SATA drives for storage, you need to install them in the case, then run a cable from them to the motherboard. The flashier M.2 SSD format is installed directly on the mobo. Make sure the mounting peg is in the right position for the length of your SSD, then remove the tiny Phillips screw, and fit the M.2 into the drive slot. Apply a little pressure to hold it down, and replace the tiny screw. Many motherboards come equipped with a heatsink for the M.2 drive—this needs to be removed before installation, then returned to the board once the SSD is in place. Don't forget to remove the plastic covering the thermal pad, or you're likely to smell burning once your build is up and running.

M.2 SSDs are installed on the mobo: Undo the little screw, and slot the drive into position.

(24) GPU Installation

The graphics card is often the bulkiest piece of gear going on to your motherboard, so take care when installing it. These cards can be heavy, and dropping one on to a board risks damaging both components. Remove the expansion slot covers from your case first, then ensure that the clip on the PCIe slot is released. Like the clasps on RAM slots, it snaps closed once the component is properly installed. Position the GPU with the rear I/O in line with the rear of the case, then gently push it down until you hear the clip. Secure it to the case with screws straight away. This principle can also be applied to other parts that are installed in the PCIe slots, such as soundcards and other expansion pieces. Be sure to use the uppermost slot for your GPU to ensure the best performance.

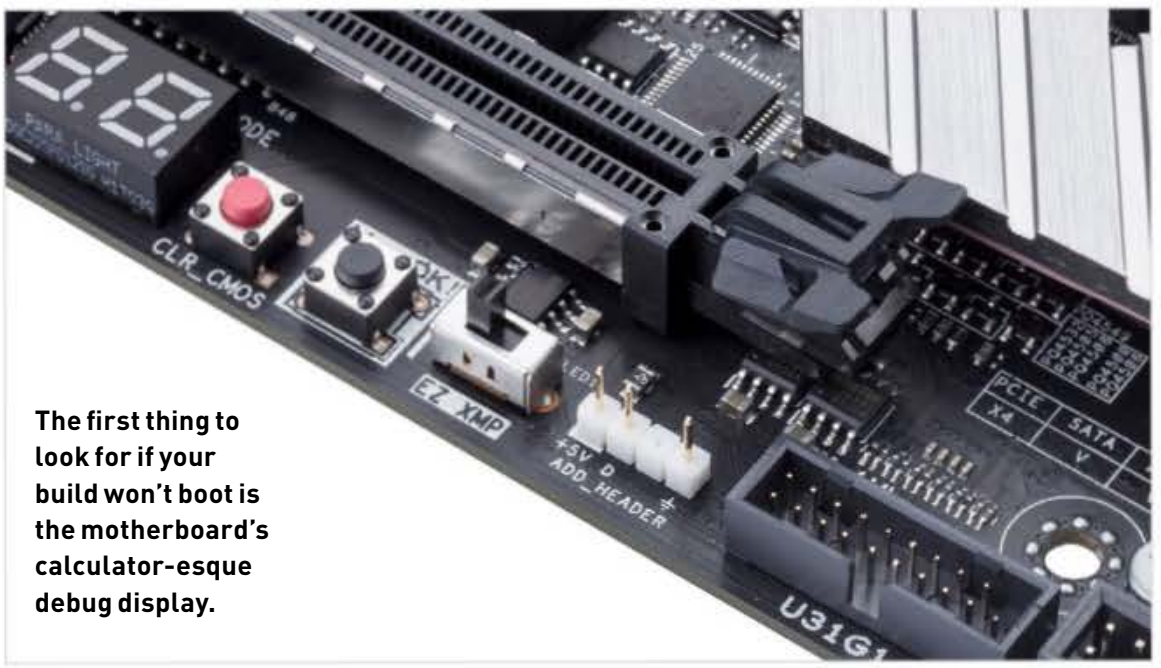
RAM installation isn't much more complicated than pushing it into place.

(25) Foggy Memory

When a build won't boot, memory is frequently the issue. If you can access the BIOS, you should be able to see whether the memory is detected properly. If not, or if it isn't seeing all of it, try removing and reinstalling the RAM. Check that the sticks are installed in the correct slots; if they are, but it's still not running, give the additional slots a try. As a last resort, try reseating your graphics card and CPU.

(26) Power On

The first thing to look for if your build won't boot is the motherboard's debug



The first thing to look for if your build won't boot is the motherboard's calculator-esque debug display.

display. Not all mobos have one—it's usually a calculator-esque seven-segment display, although some high-end boards have a small screen for displaying error codes. Take to Google or consult the motherboard manual, and you should be able to isolate the issue. If you're not sure, or your board doesn't have a display, try these next few tips.

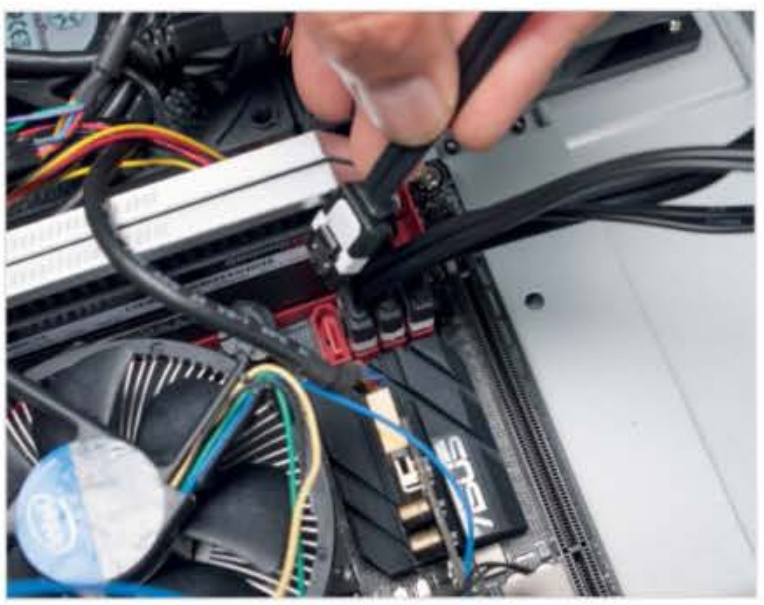
(27) Energy Checks

Is everything plugged in? It sounds silly, but we've all done it. The GPU isn't connected to the PSU, the front I/O wires aren't powered, the boot drive isn't plugged in properly. If everything looks like it's in the right place, but you're still staring at a black screen, try using a different cable for your display; HDMI and DisplayPort cables are notorious for failing when you need them most, particularly if you're using cheaper ones.

(28) OS Install

Sometimes, it's Windows that's causing the problem. This is particularly likely to occur when transferring an older drive to a new build, generally caused by driver or program conflicts, resulting in a failure to boot. OS files are susceptible to corruption, too. If this is the case, resets and updates aren't likely to help; the only option that might fix the problem is to reinstall Windows completely to your boot drive. We usually recommend installing a fresh copy of your OS with each new build.

PC not booting? Check everything is plugged in.



(29) Hardware Testing

Hopefully it won't come to this, but sometimes components simply die. If you want to do some final checks before calling the RMA line, you generally need a second (functioning) PC. You can test RAM sticks by plugging in each one separately and attempting to boot. For other components, you need to swap each one out and test it on another motherboard, or replace it with another part you're certain is functioning.

(30) BIOS Update

Most modern motherboards support updating the BIOS via the Internet, but if yours doesn't, you can usually grab the update file from the manufacturer's site. Download it on to a blank USB drive and plug it into the mobo, then find the update option within the BIOS's advanced mode. Select "Update from storage," locate the file on the memory stick, and you're all set.

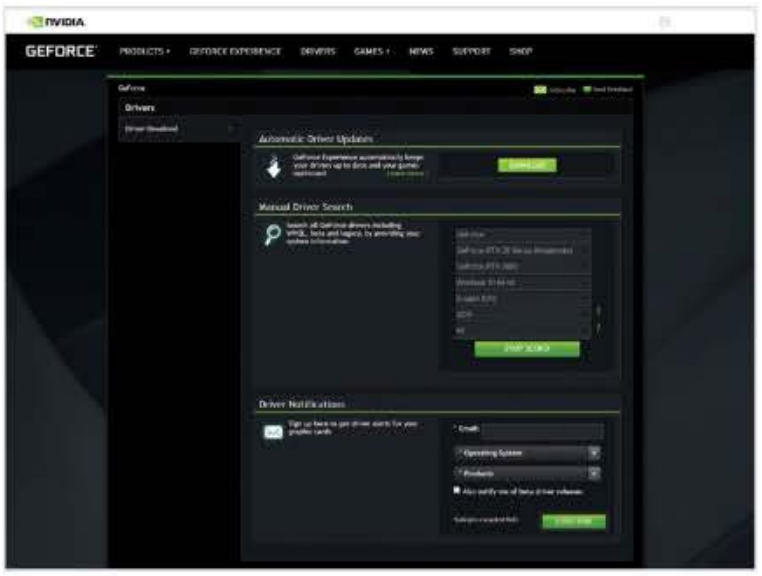
(31) STAY FROSTY

Fully customized liquid cooling can be a monster to do right, but it does come with some major advantages. Lower running temperatures are a given, generating more potential for overclocking, but the key draw for many users is the significant reduction in sound. Fans can be run slower, resulting in less noise. Creating your own liquid-cooling loop is a costly process, though, demanding a budget of at least $500 to do properly.

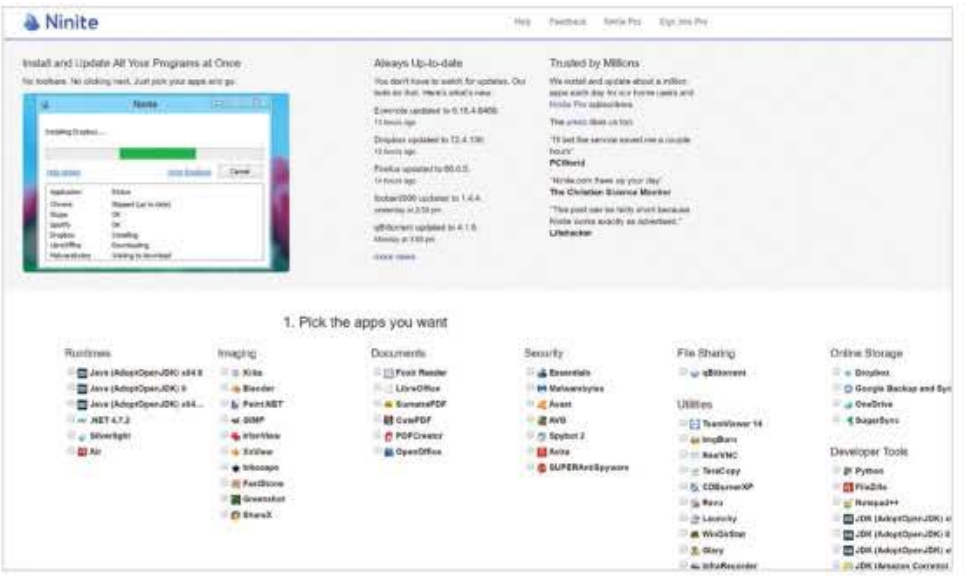
Planning out the build is absolutely necessary if you're going to be installing coolant tubes in your case. Take a side-on photograph of your case, and use your picture-editing software of choice to plan out the positioning of your components and tubes, making sure to ascertain which direction you want the coolant to flow. The larger your case, the easier it becomes; reservoirs and radiators can take up a lot of space. Smaller cases may demand the drilling of holes through metal frames to feed through tubing. Angled fittings can remove the need for bending your tubes; while flexible tubing is an option, hard tubing is easier to secure in place, and tends to look better, too.

The pump needs to be gravity-fed by a reservoir, so vertical installation within your case is required. When it comes to radiators, it's worth having at least 120mm of radiator space allocated per component being cooled. For example, if you want to cool your CPU and your GPU on the same loop, you're going to want a minimum radiator size of 120x240mm.

Filling your custom loop with coolant can be a nerve-wracking ordeal.



If you want your graphics card to run as well as it possibly can, make sure you're using the latest drivers.



Once you've built your new rig, you'll want some software to run on it; the Ninite website is a good place to source your essential apps.

(32) Installing the OS

The best way to go about installing a new OS is to grab a copy of Windows from http://bit.ly/Win10MediaKit, if you've still got your digital key (or you have a Windows 10 license connected to your Microsoft account). Download the Media Creation Tool and Create Installation Media on to a USB drive, then simply plug that stick into your new build, and boot it up. If it doesn't work, head into the BIOS and adjust the boot order, so that the system boots from the USB first. From there, just follow the on-screen prompts to set up the operating system.

(33) Update Drivers

To get your graphics up to speed, head to either the Nvidia or AMD website (depending on your GPU), and download the most recent driver update. If you're using an older motherboard, you'll want to update the chipset first. Just find the product on the manufacturer's website, and grab the latest drivers. You'll also want some additional drivers here; look for audio and LAN drivers in particular, and remember that the chipset needs to be installed first.

(34) Light Show

Custom lighting can be a tricky business. It's easy to buy an assortment of compatible RGB components and click a lighting preset in the manufacturer's own RGB control software, but if you want to go truly flashy, you're going to be installing light strips. These aren't too expensive, but you also need adapters and potentially an RGB controller, too.

When it comes to installing them, ensure that the strips themselves aren't visible from the windowed side of your case; light should always be shining on your components, rather than out of your case. Find spaces and corners to conceal them, either under the lip of the case's edges or beneath the black border of a tempered glass panel. Using two strips installed at right angles in a corner creates a more even spread of light across your motherboard, but if you're using fully addressable RGB lighting, it's important to ensure that they are synchronized up properly.

(35) Installing Software

Presumably, you're going to want to put some programs on your shiny new computer. A good one-stop-shop for this is http://ninite.com, which enables you to choose from a selection of key programs to quickly and easily download to your C drive. Ninite also keeps these up to date automatically, if you want it to. If you're a gamer, you'll likely have to do some busywork; while Steam is on Ninite's list, other platforms, such as Origin and the Epic launcher, are not. Similarly, if you use higher-end image or video manipulation software, you're going to have to seek it out yourself.

***Maximum PC's* RGB light show Dream Machine 2019.**

(36) Tweak RAM Settings

You're also going to want to take a look at your RAM settings. Double-check that the memory is running at the correct frequency and CAS timings, then enable XMP settings if you're overclocking. You can attempt to manually pump this up, too, but be careful—DRAM voltage increases of more than 10 percent can prove lethal to your sticks.

(37) Color Coding

Unless you're going for a very specific color scheme, it's generally best to stick to white lighting. This gives your components a good amount of definition, without drowning out any RGB effects your mobo is putting out. Bright single-color LED strips are likely to just highlight the predominant colors on your components, flooding your build's appearance with blue or red. If your strip allows for brightness adjustment, opting for a slightly more conservative light level is

Getting to know your motherboard's BIOS is crucial if you want to get the very best from your new rig.

a good call. Addressable RGB is great, provided you ensure that you can synchronize to retain an appealing pattern across your entire build.

(38) Search Warranty

If you can't work out what's wrong with your build—or if you can, but you can't fix it—there's one more port of call: the warranty. Most brands come with a decent warranty, and some components even come with a lifetime guarantee. Customer service is generally good—if they can't diagnose the issue, you're likely to get a fresh replacement part, provided you haven't done something horribly wrong to the offending component. Don't be afraid to raise a ticket even for minor issues; when it comes down to it, they are the experts.

In addition to general design quality and longevity, this is one of the key reasons we recommend sticking to recognizable brand-name components. If you're not sure when purchasing, check the manufacturer's website, and read some reviews on reseller sites. If you can't find many (or any) reviews, tread carefully; don't be lured in by a low price and an obscure manufacturer name.

(39) BIOS Mastery

Knowing how to modify your build's settings in the BIOS is a vital part of proper PC building, enabling you to get the absolute best out of your hardware. We deal with CPU overclocking on the right, but that's not all the BIOS can do. Fan curves are a great place to start; set a low curve (between 35 and 50 percent power) for any temperatures below 60 C, then ramp them up. This guarantees a quieter experience when your PC is idling.

(40) Speed Up Booting

There's a number of ways to speed up actual use of your PC. Fast boot or boot order settings can be useful to tweak, and ACPI settings enable you to adjust system-level power states and how they interact with input from peripherals. If you've got an Intel board, consider turning on the Rapid Start function, which speeds up resume times from PC hibernation. Remember that your operating system boots faster from an M.2 drive than a SATA one.

(41) STOP THE CLOCKS

Overclocking is a complicated business. If you're dead-set on pushing your hardware to the absolute limits, it's best to track down some serious in-depth guides on how to do so without bricking your build. Hardcore overclocking kicks the crap out of your processor and motherboard, which can result in some disastrously high temperatures if you're not careful.

At a fundamental level, overclocking is achieved by raising the frequency at which the processor runs, and increasing the voltage supplied to the components to compensate for the additional power. Different motherboards and CPUs have differing limits when it comes to the overclocks you can achieve; this is done by accessing the motherboard BIOS and manually raising the frequency at which the CPU attempts to run. Depending on the capability of the processor, this could be anything from 0.1GHz to 1GHz more. If you're running a high-end chip, you should be able to squeeze at least 0.5GHz out of it.

Keep raising the operating frequency in the BIOS. At a certain point, the CPU will refuse to boot. To get past this, head back into the BIOS and raise the voltage, usually by 0.05V at a time. Of course, doing this raises the temperature in turn. It's vital to have decent CPU cooling if you're going to overclock; a bundled stock heatsink and fan isn't going to cut it, so be sure to splash out on an upgrade.

If you've got a high-end AIO cooler, though, you can use a stress-testing program such as Prime95 to push your CPU to the limit, and assess the maximum running temps you're likely to hit. Test it between changes to the BIOS settings to ensure that you're not in danger of killing your processor—in theory, though, modern chips should shut off automatically when they reach dangerous heat levels.

After a while, you'll hit a stage where it's impossible to get the frequency any higher, regardless of the applied voltage. At this point, dial it back by 0.1GHz (this constitutes a more stable overclock), and run some more benchmarks to ensure it isn't about to die on you. If your PC crashes or you hit temperatures that exceed safe operating levels, lower the frequency by another 0.1GHz, and try, try again.

Powerful AIO coolers are a good call for heavily overclocked processors.

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THE INTEGRATION GAME

Gaming on integrated graphics is increasingly viable; *Christian Guyton* breaks down what's making it possible

IF YOU'D TOLD US at the beginning of last year that in 2019 we would get *Crysis* running on a Microsoft Surface tablet, we would have laughed in your collective face. But oh, how the tables have turned. Integrated graphics on CPUs have made huge strides in the past year. AMD has pushed Radeon Vega graphics further with its new 3000-series Ryzen APUs, while Intel rocked the boat with Iris Plus, which is its next generation of integrated graphics for mobile processors.

It was Iris Plus, included in the Surface Pro 7 convertible tablet, which managed to get that trial-by-fire game up and running. OK, it was at 720p minimum graphics, but the frame rate was still stable, and it actually worked. Esports titles, which favor frame rates above all else, thrived on Iris Plus. We played *Overwatch*, *CS:GO*, and *Dirty Bomb* on a tiny Dell 2-in-1, and it was awesome.

Integrated graphics now account for a significant chunk of all PCs worldwide, due to cost, lower power draw, and smaller profile compared to discrete graphics cards. An integrated graphics solution can now handle basic desktop tasks, but older IGPs (Integrated Graphics Processors) weren't so good for gaming. Basic 2D graphics were just about viable, but 3D and online competitive gaming required a separate, more powerful GPU.

Gaming has now gone mainstream. In 2019, 65 percent of all American adults played games regularly, with a relatively even split between men and women. And as the gaming sphere has expanded and evolved, the ability to game on integrated graphics has become a new necessity for the industry. So how has it become possible? Let's take a look.

© MAGIC TORCH

FIRST, A LITTLE background for those not so well-versed in integrated graphics. The technology has been around for nearly two decades, first in the form of graphics solutions hard-baked into motherboards in the early 2000s. These older forms of integrated graphics were competent enough to run low-intensity programs, such as word processors or web browsers, but anything involving 3D rendering was right out.

Modern IGPs are typically located on the CPU die itself rather than the motherboard, such as AMD's Accelerated Processing Units, or APUs, most recently the Athlon 3000G. These use a portion of the system RAM, unlike a dedicated GPU, which uses specific graphics memory (known as VRAM). This means reduced performance compared to most GPUs, but the upward trend in IGP performance indicates that they are closing the gap, at least at the low end.

The AMD Ryzen 5 3400G APU is roughly as powerful as a Radeon RX 550. That's a three-year-old video card with 4GB of video memory. In practice, most models of the RX 550 would likely outperform the 3400G's RX Vega 11 integrated graphics, but would do so at a higher cost and greater power draw. Paired with a decent amount of high-speed memory, AMD's current desktop IGPs perform admirably, sufficient for budget 720p and 1080p gaming.

These new integrated graphics CPUs are making affordable PC-building a reality for gamers. A low-end gaming system that would've demanded a discrete GPU just a few years ago can now be put together with a lightweight PSU and a CPU with an IGP, for a significantly lower price—granted, the cost of building a PC has dropped overall as well, with memory and storage now much cheaper than we've ever seen it, at least until DDR5 drops.

HOT COMPETITION

Most integrated graphics solutions for consumers and PC enthusiasts are available from Intel and AMD, the two big dogs in the CPU world. Both feature the integration of a CPU and GPU cores on a single processor die (referred to as SoC, or System on Chip), with Intel launching the Intel Graphics Technology product line back in 2010 with its debut of the 32nm Sandy Bridge architecture.

Thanks to IGPs, some new Surface Pro tablets are actually viable for low-intensity gaming.

AMD was quick to follow with the Accelerated Processing Unit in 2011, and secured lucrative deals with Sony and Microsoft to produce custom APUs for both the Playstation 4 and Xbox One. The lower target resolution, smaller form factor, and need for mass-production in the console industry made IGPs ideal for that platform.

The Playstation 4 was launched close to the end of 2013. Yes, consoles are frame rate and resolution-limited, but console gamers were happily plugging away in *The Last of Us* almost seven years ago. Desktop APUs that were really capable of even lightweight gaming didn't appear until 2018, with the

THE GAMES TO PLAY

It goes without saying that any 2D pixel-art game should run just fine on modern integrated graphics—even some of the lower-rent Vega IGPs from AMD. This can be a real boon for fans of indie games, many of which aren't in the least bit graphically intensive. *FTL: Faster Than Light*, *Into the Breach*, *Dead Cells* and *Hyper Light Drifter* all play great on lightweight laptops with integrated graphics. It's also a super-affordable way to play older games on modern systems; the first two *Fallout* titles run fine on integrated.

One subset of games that can thrive on integrated graphics is the burgeoning visual novel genre, which typically doesn't demand much more from a GPU than animating large 2D sprites and text against a static background. Contemporary laptop IGPs are perfectly capable of handling that workload, making great games like the *Ace Attorney* and *Zero Escape* series at home on lightweight systems. On a personal note, we'd recommend the excellent *80 Days* from Inkle Studios, a text-driven adventure game

© INKLE STUDIOS

where you play the loyal assistant of Phileas Fogg during his attempt to circumnavigate the globe in the titular 80 planetary rotations. It's a charming and unpredictable journey through an 1800s world with a steampunk twist.

Then there's the smattering of esports and triple-A titles that are specifically designed to run on systems with less RAM than a PDA from the 90s. These games may employ minimalistic lighting and particle effects, or a simplistic 3D art style that cuts down on texture loads. The likes of *Fortnite* and *Counter-Strike* are optimized to run well for just about everyone, and even games like *Apex Legends* can be tweaked to be playable on current desktop IGPs. If you're not bothered about resolution, the sky... isn't quite the limit, but you might be surprised by how much a Ryzen APU can handle in gaming terms.

Fortnite **is somewhat legendary in optimization terms, able to run on just about anything.**

arrival of the game-changing Ryzen 5 2400G; even then, many PC users didn't adopt IGPs for gaming (although a lot of this was down to poor PC optimization).

Perhaps the mere ability to access superior performance with discrete GPUs was always going to hamper the usage of integrated graphics among PC gamers, or perhaps it can be chalked down to the fame garnered by powerful graphics cards within the PC gaming community, who collectively love to salivate over the latest and greatest in graphics card innovations (sometimes even esteemed journalists like us fall under this umbrella).

Left: **The Playstation 4 uses a custom APU from AMD to produce 1080p graphics, typically running at 30fps.**

Whether or not integrated graphics truly have a place in the PC-gaming world is still a hotly contested debate. Hop onto reddit and make the suggestion that a 3200G is a perfectly good chip to play games on, and you'll be met with pleased agreement from some and utter disdain from others. It's an argument with no easy answers and strong opinions on both sides.

There's a point to be made here that gaming on integrated graphics has actually been viable for years, but PC gamers are reluctant about settling for anything less than the absolute best when it comes to their hardware. Some argue that it doesn't matter what you play games on as long as you're having fun. To criticize another gamer because they're willing to put up with lower performance than you is something of an unfair attack. But we're not here to talk about morals; we're here to talk about technology.

HOW FAR WE'VE COME

The latest iteration of IGP architecture is Intel's new Iris Plus graphics. IGPs utilizing some form of Iris graphics processing power have been around in Intel chips for a while, with the first Iris Plus CPUs arriving in 2016 under the Kaby Lake processor series as Iris Plus Graphics 640. 2019's take on Iris Plus has seen a big improvement, implemented in Intel's 10nm Ice Lake chips for mobile devices.

These chips, most commonly the Intel Core i7-1065G7, have been pushing the boundaries of what is possible on IGPs. The improvements can be seen not just in gaming but across the board, with hugely improved performance in 3D rendering, shading, and lighting. This is largely due to architectural improvements; the Intel Core i7-1065G7's on-die GPU has more than double the shading units of any previous Intel IGP, for example, and is capable of supporting up to three 4K displays simultaneously at 60Hz.

While this level of performance has yet to make it to desktop at the time of writing, it's still a huge leap forward for gaming on integrated graphics. Ultra thin and light laptops are suddenly viable for gaming; granted, nobody is going to be playing *Cyberpunk 2077* at max settings on a notebook anytime soon, but casual, indie, and potentially esports-oriented gaming will be able to thrive on this newly expanding platform.

Casual gaming is potentially the biggest market out there; globally,

BUDGET BUILDS

Integrated graphics are often the solution when putting together a cheap system, regardless of whether that system is being used for gaming. Eliminating a discrete GPU from your component list will save you a decent chunk of cash, even with low-end builds that might be using more affordable, older cards such as the Radeon RX 560. That GPU is currently available for around 100 bucks, the same price as the Ryzen 3 3200G, which comes with Radeon Vega 8 Graphics built in. A contemporary CPU to pair with that RX 560 would cost at least 50 bucks, likely closer to 100, practically doubling the price for your CPU and graphics solution.

If you're looking to build a system with integrated graphics for anything beyond the least intensive games, it may be worth investing in one of the slightly more expensive chips, equipped with either Intel UHD Graphics 630 or Radeon Vega 11—or Iris Plus, once it becomes available for desktop system-builders—which will cost a bit more but will provide superior overall CPU performance as well.

But if your system isn't going to be for gaming, there's no need to spend too much. Consider what monitor you'll be using; if it's a basic 1080p display, there's no need for the 4K support offered by Intel's UHD Graphics range. Some ultra-budget builders can even get away with spending as little as 50 dollars on the processor for cheap and easy systems, ideally using a chip that comes with an included cooler. Add in some low-end RAM, a basic ATX motherboard, and the cheapest drive, case, and PSU that money can buy, and you're sorted.

Such systems cost between $200-300 at most, and can be a great springboard into PC-building for beginners.

© SONY, EPIC GAMES, AMD

over a billion people play games on PC, although many of those people wouldn't refer to themselves as "gamers". By introducing more advanced integrated graphics to professional laptops and tablets, Intel has opened up the possibility for casual gamers to play on the devices they already own, whether that's a binge of *The Sims* or puzzle gaming during their commute.

NEW DIMENSIONS

Mainstream esports games are almost universally playable on integrated graphics. Some simply don't require much graphical oomph; titles like *Hearthstone* and *Magic: the Gathering Arena* are card-based games, so the most demanding aspects are particle effects and 2D animations. Having no 3D world to render in real time means a hugely reduced workload.

Others, as we mentioned earlier, are specifically optimized by the developers to produce performance over aesthetics. These can be twitch shooters like *CS:GO*, which forgo detailed environment textures and flashy particle effects for a zero-latency gameplay experience, as well as MOBAs and arena shooters that see a high volume of players (or AI-controlled enemies) on screen at once. In the case of the latter, simplified graphics at the design level help keep the action flowing even on older GPUs.

Above: **The Ryzen 3 3200G is a super-affordable CPU with integrated graphics, capable of 720p gaming.**

Above right: **The 2020 edition of the HP Spectre x360 is equipped with Intel's new Iris Plus graphics.**

What we've yet to see is any major esports gamers touting integrated graphics. While some professional esports teams have flirted with alternative graphics solutions, such as cloud gaming, there's been virtually no endorsement of gaming on IGPs from the esports industry and community. One British *Rocket League* team at the student esports level plays using integrated graphics, but the big players have ignored it entirely. Naturally, we don't expect the *Overwatch* League contenders to play competitively on anything but the very best hardware, but it would be nice to see some official endorsement of gaming on integrated graphics.

Why? The advancements in IGP architecture and capabilities are quickly leading to a new class of potential gamers; the adults who purchase a desktop, laptop or Windows tablet to work on, with gaming as a distant second thought. Some may not even be aware that their ultrabook is capable of playing

KEEP IT COMPACT

Integrated graphics processors are often the perfect fit for super-compact builds, pairing excellently with small, portable cases and ITX motherboards. While many ITX cases have the space for a dedicated GPU, it can often come at the expense of usable space inside the case for coolers or cable routing. Some compact cases won't support a GPU at all (or have very limited room for a video card, cooler and power supply), making integrated graphics the only option. For super-small systems in custom-designed cases, such as "themed" builds for competitions, including a GPU isn't ideal either.

Remove the need for a discrete graphics card and you won't just free up space; it can mean fewer power cables, less power draw, and reduced system weight. The latter can be vitally useful when building systems that are designed to be portable (such as one built in Lian Li's TU150 case, with its pop-out carry handle), whether it's for setting up at a LAN party or if you want a desktop for lengthy work trips. Portable PCs have never been easier to build, with an ever-expanding variety of ITX cases and motherboards available, an IGP makes that process easier.

Beyond the scope of just ITX systems,having no GPU fan helps to reduce overall noise and dust buildup too, which combined with the lower power draw can be useful for systems that need to remain powered for a long time. Extremely low-powered systems may even be able to get away with passive cooling for a zero-noise solution. Reduced TDP on modern integrated graphics processors makes them perfect for budget always-on NAS builds or customer information systems. These aren't rules that apply solely to system-building enthusiasts; they're the very reason IGPs have become the standard in tablets, home consoles, and most cheap laptops.

Above: **The Dell XPS 2-in-1 is impressively competent when it comes to esports gaming at 1080p. *Rocket League* can stress older IGPs, but modern ones should be able to handle it.**

Above left: **Basic textures and a cartoony art style means that *Overwatch* can still run well on lower-spec systems.**

modern games. These people represent a relatively untapped reserve; gamers who perhaps don't think they can afford a 'proper' gaming PC.

AMD and Intel seem to be aware of this, and their processors with integrated graphics are advertised as such. AMD touts its Radeon graphics on third-gen Ryzen chips as having "the power to play", while Intel refers to its Iris Plus chips as having "the performance needed for 1080p gaming". The same is true of laptop manufacturers, to a lesser extent; brands like Dell and HP always acknowledge the improved performance of 2020's updated Iris Plus graphics on their products.

But when it comes to the actual gaming sphere, there's little fanfare about the quickly improving performance of IGPs. Integrated graphics still have virtually no representation among the gaming "elite": the Twitch streamers, the YouTubers, the esports pros. The potential for new, more powerful integrated graphics to broaden the scope of gaming as a whole, bringing more people into the wider community, is huge—but currently under-utilized.

WHERE TO NEXT?

This is slowly changing, though, as integrated graphics technology catches up to the discrete GPUs of yesteryear. It seems unlikely that IGPs will ever overtake discrete graphics cards in terms of performance, if only due to the size restrictions that affect on-die graphics solutions, but IGPs may be improving at a faster rate than discrete GPUs right now. The future of integrated graphics is uncertain, but it seems that we're still on the up and up; while that rate of improvement is bound to slow eventually, it looks like IGPs will continue to innovate for a while yet.

One example of this continued improvement is Intel's upcoming Xe GPUs. The Xe architecture will be available in discrete GPUs at some point in the future, but before that we'll see the same graphics technology in the upcoming 10nm Tiger Lake CPUs, which are expected to launch sometime in late 2020. OEMs will have the first opportunity to use these chips, so the first we'll see of Xe graphics will likely be an IGP version in laptops.

The discrete Xe cards are obviously the big news here—and Team Blue entering the GPU game to duke it out with AMD and Nvidia is a very exciting prospect for us, too—but when Intel senior VP Raja Koduri discussed Xe during Intel's 2019 Software Technology Day, he was keen to emphasize that there would be Xe solutions for everything from low-end integrated graphics to datacenter hardware and performance gaming GPUs. Considering that Intel just upped its game with the new and improved 10th-gen Iris Plus graphics, we're excited to see what it does next.

4000: A CPU ODYSSEY

Perhaps before we even get a glimpse of Xe, though, we might see AMD come scorching back into the lead. With the Ryzen 4000 series just now hitting laptops, and with desktop parts currently unscheduled but bound to follow, we've actually got hands-on with these very chips this issue (see pg68). With AMD promising up to 28-percent improved graphical performance over Intel's Ice Lake CPUs, we're excited to see if the rumors are true.

The new U and H models of the Ryzen 4000 series vary quite substantially, with some featuring hyperthreading while others boast impressive boost speeds. These chips will be the first 7nm processors to make it to laptops, with early leaked benchmark figures indicating that the performance is close to third-gen desktop Ryzen parts. We'll likely have to wait a while to see the super-shiny new Zen 3 CPUs arrive on desktops, but that will likely bring even better levels of IGP performance—that is, assuming that AMD doesn't use older architectures for the APUs, as it has done in the past.

Whatever happens next, we're excited to see it. With steady improvements every generation for both AMD and Intel IGPs, it's not unlikely that within two to three years we'll see integrated graphics that are capable of running most games at 1080p 60fps, not just low-poly indie titles and uber-optimized esports giants. Where we'll get to beyond that is harder to predict; will IGPs capable of handling 1440p gaming emerge this decade? 4K, even? We fancy those odds. Wherever integrated graphics go, it'll be good for gamers.

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Could dedicated GPUs become a thing of the past? Probably not, but IGPs are still cool.

BROWSER WARS 2020

As Google Chrome crushes all its browser competition, we take an in-depth look at what makes it so good and why you shouldn't be using it. ***Neil Mohr***

WE SUSPECT most *Maximum PC* readers remember with bitterness and rolling of eyes the Browser Wars of the year 2000 (OK, perhaps it's more like 1995, but we like round numbers). Back when websites were websites, adorned with user-unfriendly "Compatible with Netscape" logos and "Under Construction" animated GIFs, that took an age to load over crawling 56K modems. Entire websites that only worked with a flashy plug-in, and Microsoft breaking standards left, right, and center to gain market share. Great days, if by great you mean awful.

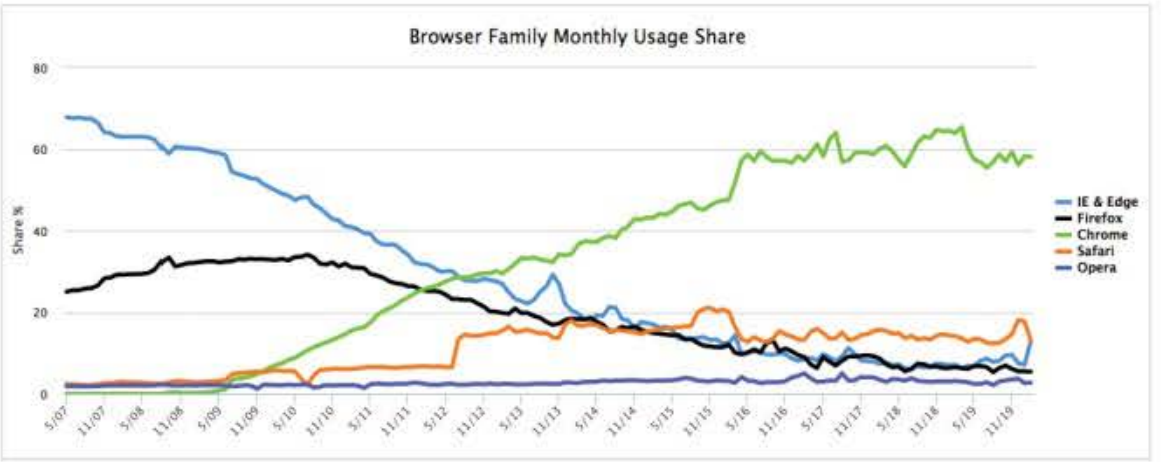
You have to hand it to Microsoft—and, indeed, Bill Gates—who foresaw the dominant role the web browser would play in the future, and yet still manage to entirely throw away that market-dominating position to some plucky underdog called, of all things, Google.

Why does it even matter which web browser we choose? Why has the browser become so powerful? What makes a web browser tick, and is there really any difference between them? All of these questions and more will be answered as we dive inside the web browser, benchmark a bunch of them, and ask experts, "Should we be sticking with the browser shoved in front of us by globe-spanning corporations?" Hint: No.

WE'RE NOT ABOUT to take you back to 1993 and explain the history of the world wide web, aka Web 1.0. That's done and dusted—thanks, Tim Berners-Lee. We're jumping straight into the "today" to explore what makes a modern web browser tick, because the differences are vast. The important question to ask is why? What has changed so much over the last 27 years or so that makes modern browsers so complex?

To kick things off, and to perhaps whet your appetite, just considering the basic high-level functions of a web browser reveals a corresponding high level of complexity. Part of this is the network connectivity to fetch all the HTTP and associated protocols, before you can even consider displaying anything.

Even at this stage in the explanations, what we need to understand is that the world wide web is a precarious stack of standards, piled on top of each other, and transmitted over an international-scale network. If any corporation or nation state decides that it wants to interfere with them, things quickly begin to fall apart. Just take DDoS attacks, or certain countries rerouting all traffic by abusing Border Group Protocol hijacking. On a more relevant level, if a major browser provider wants to undermine open standards, it certainly can—and definitely has done.

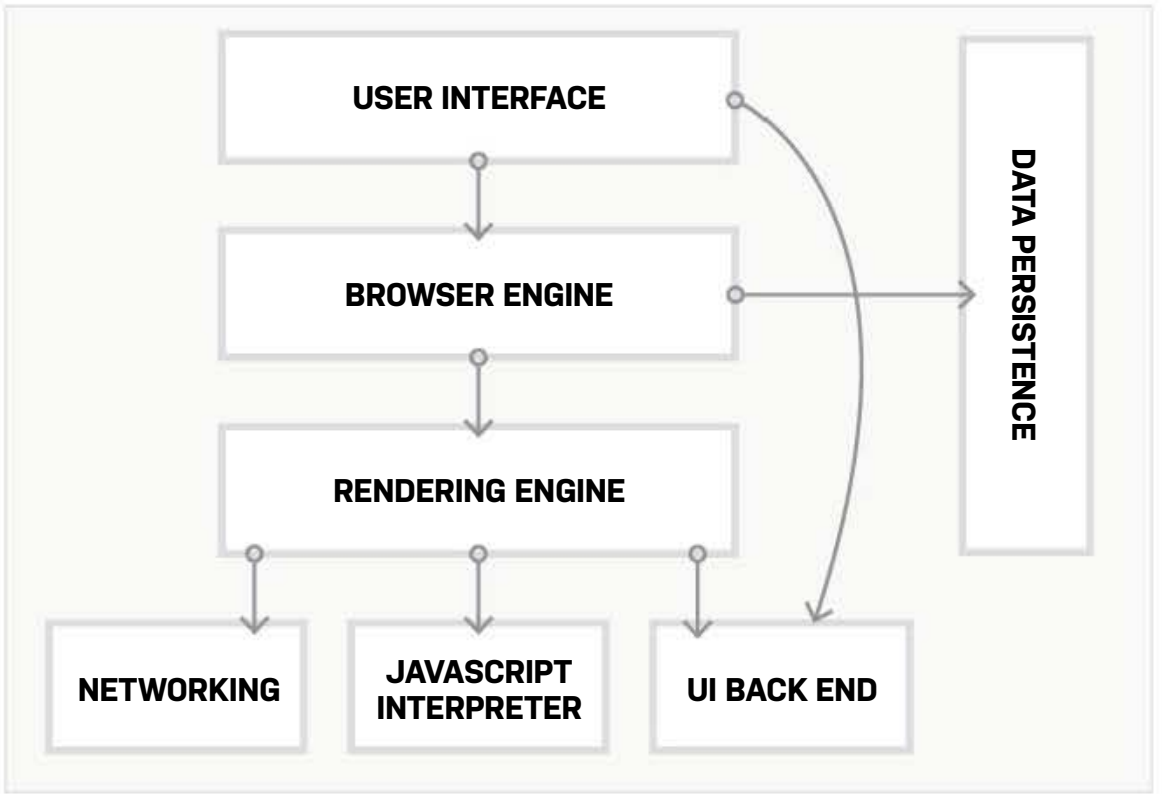


A single browser always dominates the desktop landscape.

INSIDE A BROWSER

The basic overview of a browser hasn't changed much since the first ones launched in the mid-1990s, the main additions being support for processing JavaScript and local data persistence. Check out the diagram below to see how a browser is built.

- **NETWORKING** There's a lot of fetching and carrying with a web browser. HTTP(S) is the core, but there's FTP for file transfers, SMTP for basic email, and DNS to look up URLs and request pages from the web server. Not to mention TCP/IP connections and packet transfers.
- **USER INTERFACE** You probably take it for granted, but the interactive decorations around the browser and additional features it may offer—such as bookmarks, history, password storage, and more—are all part of the interface.
- **BROWSER ENGINE** This is less obvious than the rest, and refers to the intersection between the user interface element and the rendering and Java engine, while also linking to the data storage element. For maximum confusion, some projects refer to the browser engine, while others talk about the rendering engine.
- **DATA STORAGE** While this started with cookies, local data storage is far more important in modern browsers for use in local applications. Web Storage provides basic local variables, but Web SQL offers full local database features, with an Index database being a compromise between the two.
- **JAVASCRIPT ENGINE** The programming language of the web, JavaScript enables interactive websites and dynamic content. While it's designed to be interpreted, modern browsers use a Just In Time (JIT) compiler that runs the code on demand, to be as fast as possible. Each major browser uses its own engine, which can offer a performance differential.
- **RENDERING ENGINE** The core block of any modern browser—we'll take the majority of our time digging into how this works, which will involve another block diagram. Effectively, this is two parsers: one processing the HTML and Document Object Model (DOM) elements, and the other parsing the Cascading Style Sheet data. From this, a rendering tree is generated, laid out, and painted to the display.



The basic parts that go into powering a browser.

SAME BUT DIFFERENT

We're going to largely ignore parts of this model, such as networking, the user interface, browser engine, and data storage. It's not that they're unimportant—that's absolutely not the case—but they're more openly duplicated between systems. Accessing the TCP/IP networking stack and requesting/sending HTTP is donkey work done by standard libraries. Finesses of a user interface are better left for a critical review or group test. And while we'll mention browser storage, we're not going into any deep analysis of it.

This leaves us with the two main elements that dictate performance and compliance: the JavaScript engine and the rendering engine.

We're going to focus on the rendering engine because it's big and complex. But why all the fuss in the first place—isn't HTML just HTML? As we alluded to, the web and online applications are built on standards; in the case of HTML, it's the

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WHAT SUPPORTS WHAT

Browser	Renderer	JavaScript	Status	Developer
Chrome	Blink	V8	v80	Google
Firefox	Gecko (Quantum)	SpiderMonkey	v73	Mozilla
Safari	WebKit	JavaScriptCore	r91 (v13.1)	Apple
Internet Explorer	Trident	Chakra	v11	Microsoft
Edge	EdgeHTML	Chakra	v44.19041	Microsoft
Edge (2019+)	Blink	Chakra	v80	Microsoft
Opera	Blink	V8	v66	Opera Software
Brave	Blink	V8	v1.4.95	Brave Software

An at-a-glance guide to the building blocks of browsers laid bare.

World Wide Web Consortium, aka W3C, that defines the guidelines on what each HTML tag should do.

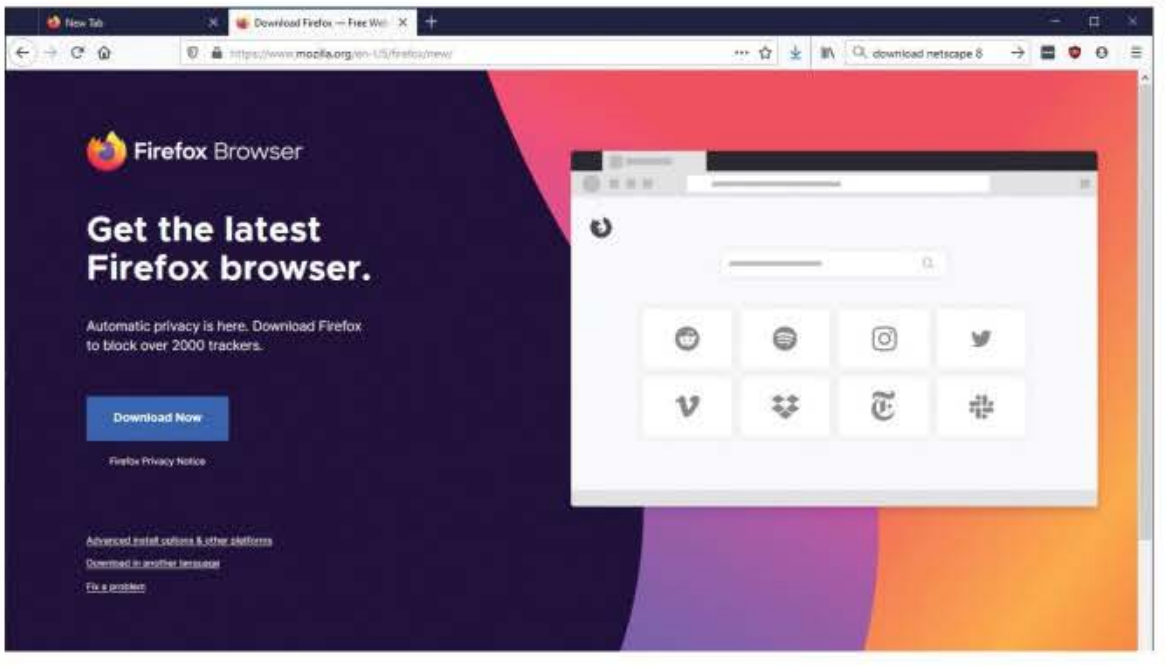
The problem is, as with so many aspects of life, guidelines and rules are open to interpretation, and what one browser might do with a certain set of tags, another does not, and dumb humans do a whole other set of things, too. As the rendering engine is in charge of interpreting and displaying content, and as different browsers use different engines, that content can end up being displayed differently from browser to browser. Usually, this is minimal, but sometimes it can lead to positional changes or, at the extreme end, entire pages failing to display.

Oddly, many quirks of rendering are down to how engines handle error conditions, because this behavior is not standardized. HTML editors and humans can output all manner of crazy, non-compliant code that the poor browser engine then has to parse and interpret as best as possible, as we'll now examine.

SKINNING CATS

The network engine is doing its thing and fetching web page content, then passing it to the rendering engine. At this point, there are two main ways of handling the content. We're going to look at how WebKit and Blink deal with the process, but be aware that Gecko, used by Firefox (and derivatives), approaches things in a slightly different order.

Both, however, split the website data into HTML and CSS data—these will be processed separately by their own parsers. What's that, then? Roughly speaking, a parser takes in the incoming bitstream and translates the data into a node tree; the structure of that tree is defined by the syntax (rules) of the language (HTML or CSS). If you're aware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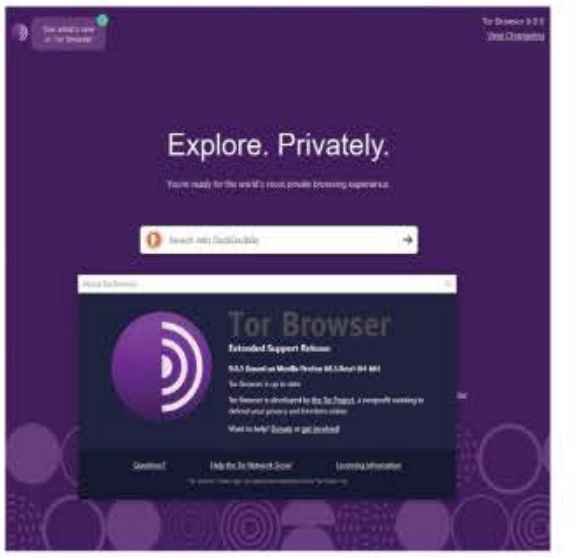


BEST FOR PRIVACY

Why should you care about privacy? Well, Google, Amazon, and Facebook know everything about you—probably because you told them. Google, because it owns your life now; Amazon, because it owns your shopping habits; and Facebook, as it owns your social networks. The idea that you should use a Google-branded browser that helps you to log into your Google account before you browse anywhere should be ringing alarm bells. The same should go for a browser produced by the company that also developed your operating system. This sort of duality of function is begging for total surveillance.

In terms of privacy, Mozilla's Firefox is hard to beat. Firefox, based on the Gecko engine, has been around in one form or another since 1998. Mozilla is an open-source organization dedicated to protecting an open Internet and user privacy. So, with Firefox's combination of cutting-edge performance, sweet suite of features, and mindfulness of privacy, you'd be foolish not to be using it as your daily driver.

There is a step beyond this, though: the Tor browser. It's based on Firefox, but utilizes the anonymizing Onion network to hide your browsing inside a bundle of encryption. The downside is that it's slower and has various issues confusing web hosts. It's also worth considering one of the feature browsers (see page 43); as none is connected to a large corporation, they're far more likely to take your privacy into consideration.

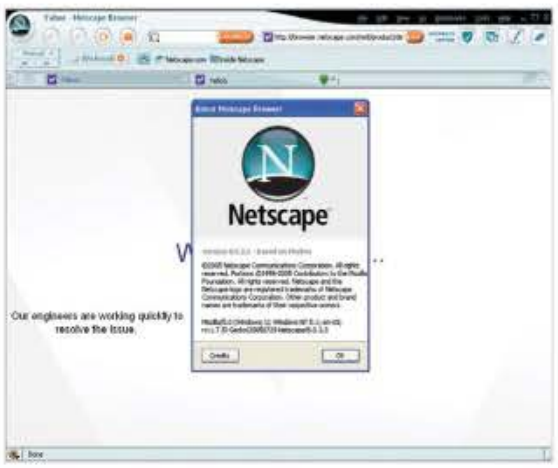
BROWSER BENCHMARKS

Browser benchmarks have been around for a good many years; you might remember SunSpider—released in 2007 and very much outdated now—which is still available. It's been superseded by Mozilla Kraken in terms of providing a similar suite of tests, while JetStream, developed by Apple, is a dedicated JavaScript benchmark tool, with version 2.0 housing a Web Assembly benchmark; it's in part based on the previous benchmark, Octane 2.0.

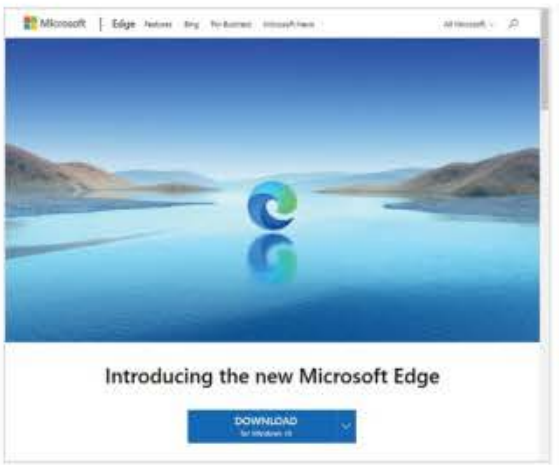
Both of these measure how quickly the JavaScript engine can manage a suite of basic tasks. By using a wide range of different types of loads, it protects the benchmark against engine optimizations. If you look into the tests, you generally find they're math-heavy, compiling libraries, testing crypto libraries, ray tracing, and compression tests.

As you'd expect, the newer the browser, the faster the results, but due to the more recent Web Assembly elements of JetStream 2, this benchmark failed to complete on "older" browsers, but that even includes the EdgeHTML browser that stalled on the final test. We added Internet Explorer 11, as it's still supported, and the Blink-based keyboard-oriented Qute.

Browser	Kraken (ms)	Jet Stream 2.0	Memory (MB)
Brave	977	108	386
Chrome	980	105	556
Edge (old)	1,136	N/A	192
Edge 2020	974	104	314
Firefox	852	82	531
IE 11	2,179	N/A	67
Qute	1,066	105	323



Browsing the web, 2005-style. Not fun.



Edge is dead, long live Edge (Blink-powered).

of basic HTML tags, it should make sense to say the parsing process is split into:

• **A LEXER** This breaks the input into known tokens (tags) based on the vocabulary rules.

• **A PARSER** This constructs the document tree following the grammar rules. A token is requested from the lexer; if it matches a known rule, it's added to the tree, else it's stored and another token is requested. If no match is found for a stored token, an error is raised.

HTML is interesting in terms of languages. It has a loosely defined grammar, because it has to be backward compatible and fault tolerant, while it has to deal with dynamic code (via scripts) that can add tokens back in while it's being parsed. This means its parser can't use a systematic top-down or bottom-up approach to parsing. In the language world, people say it's not a context-free grammar—we might call it other things, given half a chance.

To give you a taste of what a web parser has to deal with, let's quickly look at a very rough day-in-the-life of an HTML lexer. It starts in its default "data state" mode, when a < is encountered that switches to "tag open state" mode. Characters a–z encountered next create a "start tag" token and a "tag name state." This continues until a closing > is hit and "data state" mode is back. If a / is encountered after a < then an "end tag token" is created until the > is hit.

These tokens are passed to the HTML parser to be constructed into the document tree, as and when each suitable HTML tag is encountered, from <HTML> to <BODY> to </BODY> and </HTML>.

What we find more interesting than this is what the heck browsers do when they encounter not just badly formatted HTML documents, but downright illegally formatted documents. A browser parser has to be "fault tolerant," else web pages would just fall over and fail to load. At a minimum, a browser needs to know what to do if a <tag> isn't closed </tag> correctly, which happens all the time. Beyond this trivial example, it needs to know what to do if it encounters an unknown tag, an out-of-date tag, or tags used in a non-compliant manner.

There's no official definition of how to handle erroneous HTML code, but Apple's WebKit code has a number of interesting comments that explain its approach to various classic mistakes, including unclosed or incorrectly closed tags, badly nested tables, highly nested tags, and incorrectly terminated <body> tags.

Ultimately, the HTML processed by the parser will result in a Document Object Model, aka a DOM tree. Separately from the HTML, the CSS element of the page will also be parsed into a CSS Object Model tree. Unlike HTML, CSS is a context-free grammar, which makes it more difficult to break by silly humans. The parser has to process the CSS to determine the style of each element. This isn't a CSS tutorial, so we're not going to look into the details of the language here.

We've alluded to dynamic content and scripts. Really, <scripts> don't change much, but browsers are supposed to handle scripts synchronously—parsing stops until the script has been executed. If networked resources are required, these need to be loaded, and everything should be halted until they have been. Script authors can add a <defer> to wait until the document is parsed before it's executed.

However, WebKit and Gecko utilize speculative parsing to read ahead and load any network-based resources, such as scripts, images, and CSS, to avoid stalls in page loading. This is smart, as scripts that request network-loaded style sheets cause issues if they can't be reached.

RENDER TREE

Things are starting to heat up. We know where things are in the page from the DOM tree created from the HTML. We also know how things should be styled from the CSS Object Model tree, created from the CSS. Each render object is a literal

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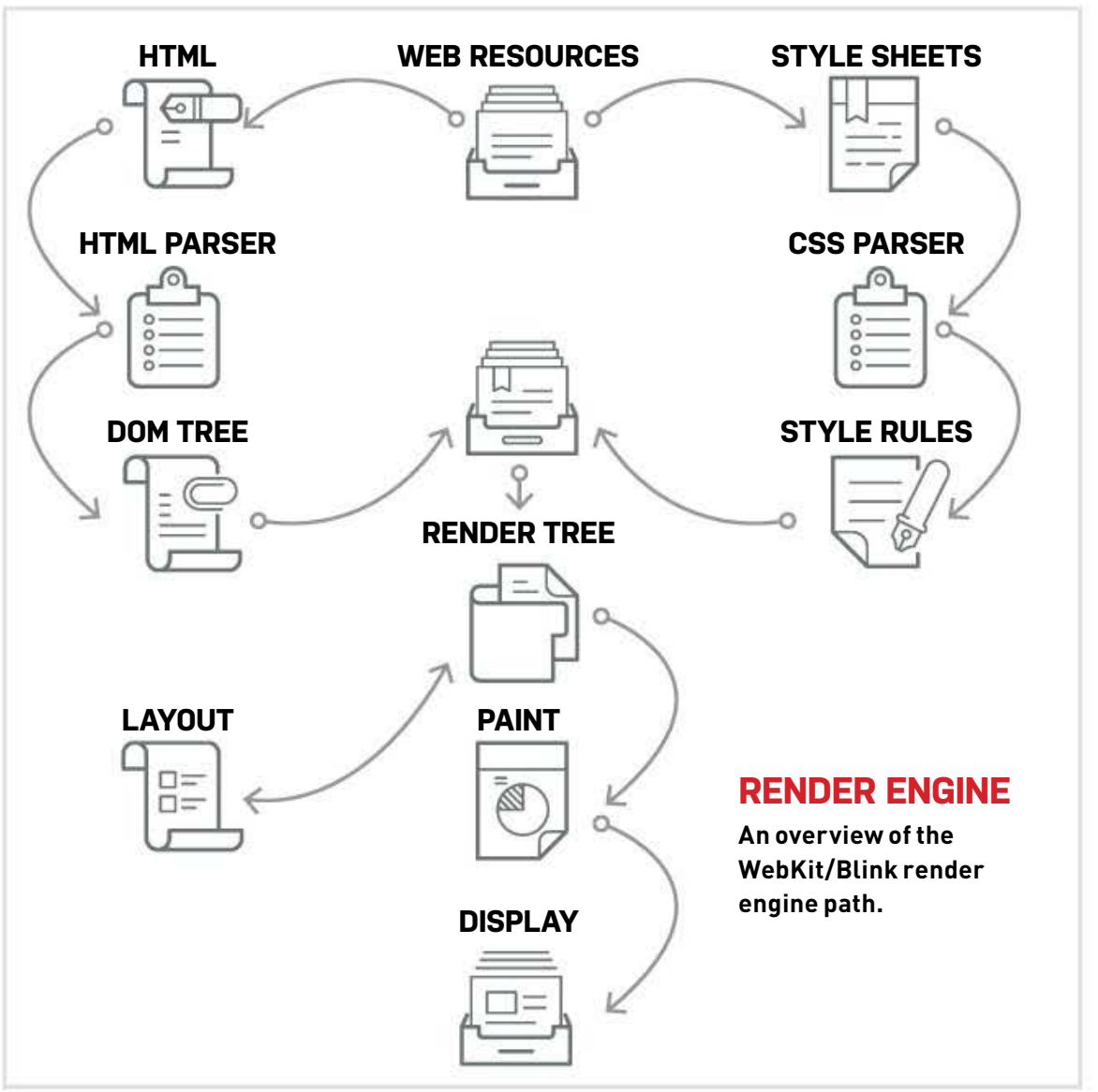

RENDER ENGINE

An overview of the WebKit/Blink render engine path.

rectangular area of specified size and position, with an attached style. Many objects are actually constructed from many rendered rectangles; the important thing to remember is that the render tree is constructed from the DOM tree.

We should point out that matching a style to a render object isn't as straightforward as you might think, depending on how rules are inherited. And how the browser has to process inherited style rules and match them to objects can take a great deal of traversing trees.

Now layout can begin. This is the process of calculating exactly where those rectangles will go with the applied style. HTML is devised so layout can be done in a single pass, moving left to right and top to bottom. Layout can be recalculated on a global level (such as a global style change or window resize), or if "child" objects flag that it needs recalculating. Finally, the render tree can be "painted," and is handled by the UI elements of the browser, because it's reliant on the OS.

POWERING THE WEB

We've already mentioned that all modern browsers run JavaScript, with a JIT compiler for maximum speed. Each browser has its own JavaScript engine, and this enables you to "program the web" and create all the advanced interactive online applications. But JavaScript has its origins back in the 1990s, when no one really knew what it was going to be used for—so, say hello to Web Assembly.

Launched in 2015, it was available in most browsers by 2017, and was standardized at the end of 2019. It enables a low-level, cross-platform language that runs natively on the hardware via the browser. You can compile C/C++ and Rust to Wasm (Web Assembly). It runs in the same sandbox as JavaScript, so can be leveraged by its libraries for effectively free speed-ups.

Web Assembly is available in all the mainstream browsers, and the fact that it runs on the native hardware should offer an indication of the speed-ups developers know it will deliver over interpreted JavaScript.

At this point, you have an HTML5-compliant webpage, with all the dynamic Web 2.0 spinning wheels you could ask for. The world (Google, Apple, Microsoft) appears to be settling on a WebKit/Blink-based browser world, which is good for compatibility, and doesn't stop others offering spin-offs. We dearly hope Mozilla retains the independence of Firefox, but it feels like it's now fighting an uphill battle. The browser wars will return.

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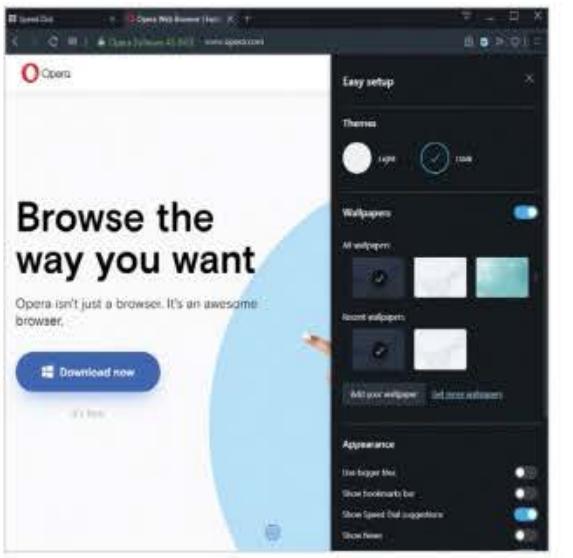

RISE OF THE FEATURE BROWSER

With the major browsers all tending toward one or two rendering engines, and the advent of Web Assembly reducing the importance of any JavaScript engine superiority—though, again, many browsers also reuse the same JavaScript engine—the question does arise as to what differentiates browsers today.

We've already covered a key difference, and that's privacy. Simply not being Microsoft or Google should be an attractive feature in itself. There's a group of browsers out there that utilize the Google Blink engine and the V8 JavaScript engine, but offer a set of unique extra features to lure users in.

The original alternate browser is Opera. Still going strong, it switched from its own Presto engine to Blink around 2003, maintaining both options for some time. Opera has retained a 2.5 percent market share for most of its life, from the mid-1990s, so has a dedicated following.

Brave is one of the new generation of modern browsers. Its schtick is partly privacy, partly a shared ad revenue system, and it leans on the bonus that protecting privacy enhances device battery life and extends your data plan. It's based on the Blink and V8 engine.

Vivaldi was launched in 2016 by the co-founder of the Opera browser, who wanted to reclaim features of Opera lost by its switch away from the Presto engine—though, ironically, Vivaldi uses the same Blink and V8 engines. It pushes a unique streamlined interface that many find refreshing and intuitive.

TECH PORN

PERFORMANCE GEAR LAID BARE

Corsair One Pro i200

WE'VE LOOKED AT a previous model of Corsair's iconic One desktop tower before, but this might be the best version we've seen. The Corsair One Pro i200 is somehow retailing at the same price as the previous i180, despite having a newer, powerful, 10th-gen Intel Core i9 CPU and double the memory (a whopping 64GB). It also comes with the same RTX 2080 Ti graphics card, and a high-speed 2TB M.2 SSD.

It's not explicitly a gaming machine, though. While it might have the power needed to chomp through 4K gaming binges, the small form factor, subtle lighting, and muted metal finish all contribute to a clean and professional aesthetic. This is a system that can comfortably occupy a modern home office, and handle whatever work you want to throw at it.

3D rendering, 4K video editing, sound mixing? The i200 is all over it. There are few pre-built desktop PCs on the market that can match this on performance, and if you're looking for a compact form factor, the i200 is the one to beat. A Mini-ITX X299 motherboard and GPU solution that sees the card attached via a flexible PCIe adapter mean that the footprint of the i200 is fantastically small—less than seven inches across.

Yes, it costs four and a half grand, but there's nothing out there quite like it; a slender tower that runs softly with its dual AIO coolers, but has the hardware necessary for the toughest number-crunching tasks and high-end gaming. This is what the powerhouse PC looks like in 2020. –**CHRISTIAN GUYTON**

1 FBI, OPEN UP

Cracking open the Corsair One Pro i200 left us just as impressed as previous models. The twin radiators are mounted on the external panels, which lift off easily once the screws at the top are removed. The motherboard assembly is breathtakingly compact, and the tiny PSU at the base supplies a solid 750W of power to the system.

2 PLUG IN

The One Pro i200 comes ready for maximum connectivity. The minimalist front I/O offers two USB-A ports, a headphone jack, and a HDMI port for VR headsets. The rear I/O is even better equipped, with DisplayPort, 7.1 audio, USB-C connectors, and more.

3 COOL & COMPACT

The i200's primary cooling matches that of previous Corsair One models, using a large 140mm fan in the roof of the case, and an AIO cooling setup for the processor and graphics card. It's a simple cooling solution, but it works well, the i200's vertical design ensuring maximum airflow through the case.

4 BRIGHT LIGHTS

This workstation is no gaming rig, but Corsair couldn't resist squeezing in a little bit of RGB. Two clean lightstrips run down either side of the i200's front panel, emitting a soft blue glow by default. This can be customized in Corsair's iCue software, but we like the simple stock aesthetic.

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BROWSER BEATDOWN
Chrome, Firefox, and Edge tested. Which one will be king? PG. 38

2

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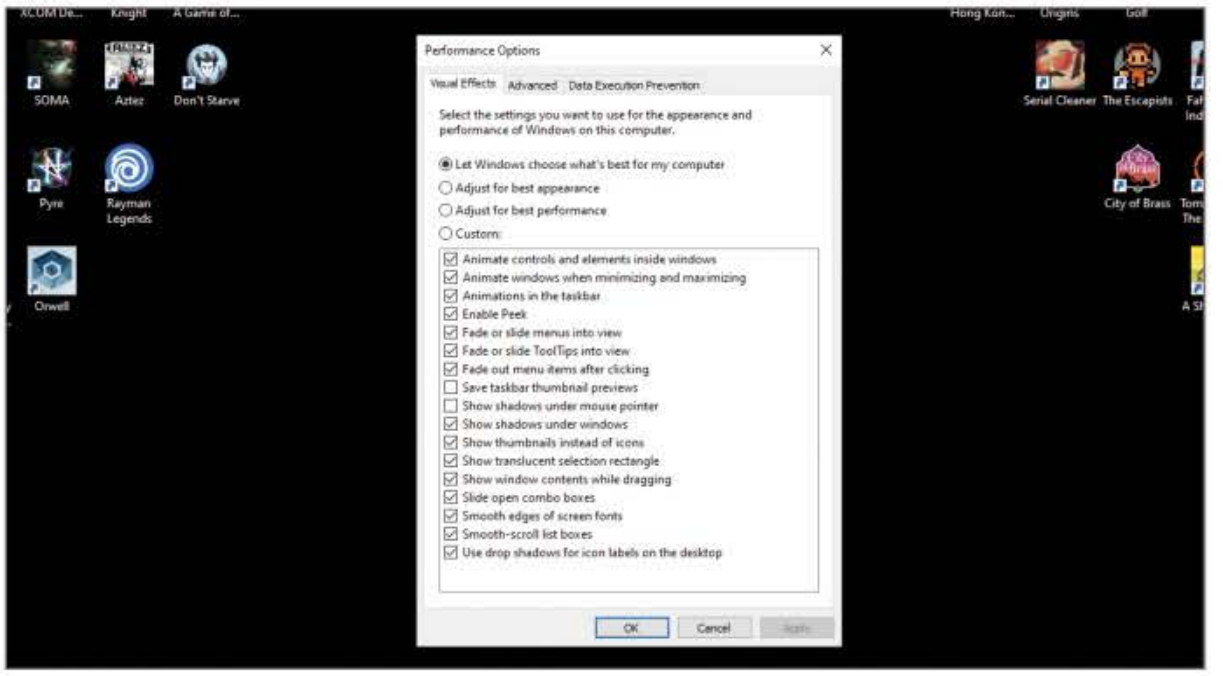
HOW TO

STEP-BY-STEP GUIDES TO IMPROVING YOUR PC

TIP OF THE MONTH



DISABLE VISUAL EFFECTS ON SLOWER SYSTEMS

The smooth visual effects of the Windows 10 UI make for a pleasant user experience, but those brief animations can have a significant impact on performance on older (or budget) systems. Search the Start menu for "adjust the appearance and performance of Windows" to find the relevant Control Panel page, then select "adjust for best performance" to banish those animations and speed up your system.

MAKE – USE – CREATE

52
Create a digital diary with Lifeograph

58
Benchmark your CPU like Maximum PC

60
Build the perfect 1440p gaming PC for $2000(ish)

© MICROSOFT

CHRISTIAN GUYTON
STAFF WRITER

UPGRADES, PEOPLE

I've been talking about building a new home PC for months, and silently thinking about doing it for far longer. The chunky rig that sits on my desk at home is an old Lenovo prebuild that I've upgraded piecemeal over the last couple of years; a bump from 8GB to 16GB of memory in 2018, swapping out the hard drive for a faster SATA SSD in 2019. I thought 2020 would be the year I upgraded the CPU or GPU, but life had other plans.

As I write this from COVID-19 self-isolation, praying that things are better by the time you read this, I wish that I'd simply sucked it up and assembled a whole new system from scratch. This case was built for style over performance, with only two case fans and little room for more. It has a disk drive! I write for one of the biggest computer hardware magazines in the world, and I'm still rocking the Intel Kaby Lake Core i5 processor that came with my four-year-old prebuilt system.

Perhaps the ability to perform smaller upgrades is what makes PCs better than other platforms. Whether it's Macs for work or consoles for gaming, nothing has the level of flexibility of a PC, especially one you've built yourself. So if you're still plugging away on an old, prebuilt PC, consider: shall I upgrade slowly, or is it time to start afresh?

↘ submit your How To project idea to: comments@maximumpc.com

IFIXIT presents:

AUTOPSY

THIS MONTH WE DISSECT...

Sony Playstation

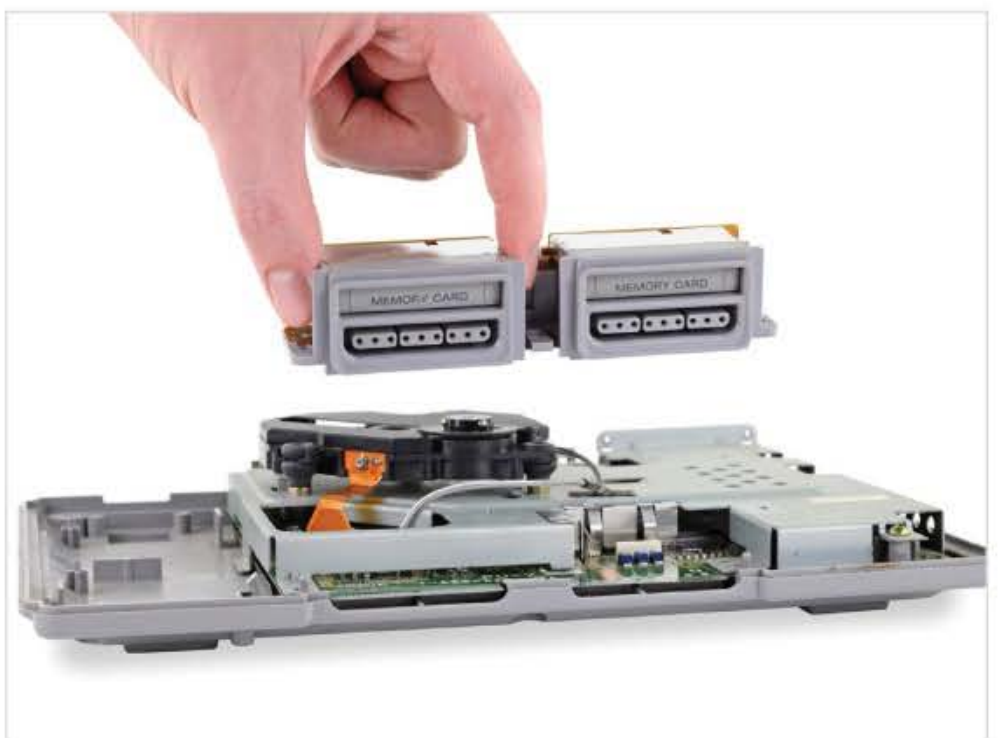
Despite the Playstation's small size, Sony was able to cram this PSU in here without breaking a sweat.

About iFixit

iFixit is a global community of tinkerers dedicated to helping people fix things through free online repair manuals and teardowns. iFixit believes that everyone has the right to maintain and repair their own products. To learn more, visit www.ifixit.com.

This Playstation is commonly referred to as the "PSX" because "Playstation X" was its codename during development. The name stuck even after the X was officially dropped.

The 1MB Playstation memory cards were split into 15 separate memory blocks.



BACKGROUND

Originally developed as part of a joint venture between Sony and Nintendo to make a CD-equipped SNES console, Playstation is now one of the world's most recognized brands. For its 25th anniversary, we got our hands on the unit that started it all, the Japan-only SCPH-1000 model. We're celebrating the only way we know—time to tear it down!

MAJOR TECH SPECS

- MIPS R3000 33.9 MHz, 32-bit RISC CPU
- 32-bit GPU
- 2MB RAM
- 1MB VRAM
- 16-bit 24-channel PCM stereo sound
- 2x CD-ROM Drive

KEY FINDINGS

- The Playstation was only available in Japan during its first year on the market. The most noticeable cosmetic difference between the Japanese and North American models is the Playstation logo on the lid. The Japanese model sports a bit of green instead of the Playstation blue, as well as a brownish color in the logo's negative space.
- So how do we get inside this thing? It turns out each screw holding the two halves of the console together is marked with a little arrow! These helpful pointers are a breath of fresh air. Actually the air is pretty dusty—this thing is old.
- We lift the lid off, hoping that gems will fly out for us to collect. We're left empty-handed in the gems department, but there's some pretty cool stuff here. First, let's carefully dispose of this power supply before we get zapped. This internal power supply takes up roughly 20 percent of the console's footprint. 90's silicon didn't run as hot as today's hardware, but it's still impressive to see an internal power supply, an optical drive assembly, and everything on the main board running in a fanless configuration.
- Next up, the controller ports and memory card slots come out as one assembly. The CD laser and motor assembly rests on three pegs, secured in place by rubber grommets. This allows the entire mechanism to move around slightly and absorb vibrations from the spinning disc. In case your mother never taught you: NEVER TOUCH THE LENS.
- With nowhere left to turn, we lift up the giant metal shield hiding the motherboard to reveal the main act. Like Lara Croft, we carefully lift this dusty relic from its home, hoping we haven't tripped a booby trap. To our relief, it appears we haven't sprung any. We've struck gold here—this thing has more chips than three bags of Tostitos... and flipping the motherboard over reveals a few more.
- And that's it! There's not much inside this Playstation, which is a testament to Sony's design and engineering chops—or maybe technology was just simpler back then...
- Repairability 8 out of 10 (10 is easiest to repair). The console is made up of few components, and each one is straightforward to remove and replace. Only a Phillips screwdriver and a spudger are needed for complete disassembly. The optical drive is one of the easiest components to remove. Since the Playstation has been around the block a few times, repair and service information is widely available. All of the I/O ports on the back of the console are soldered to the motherboard.

Create a Digital Diary with Lifeograph

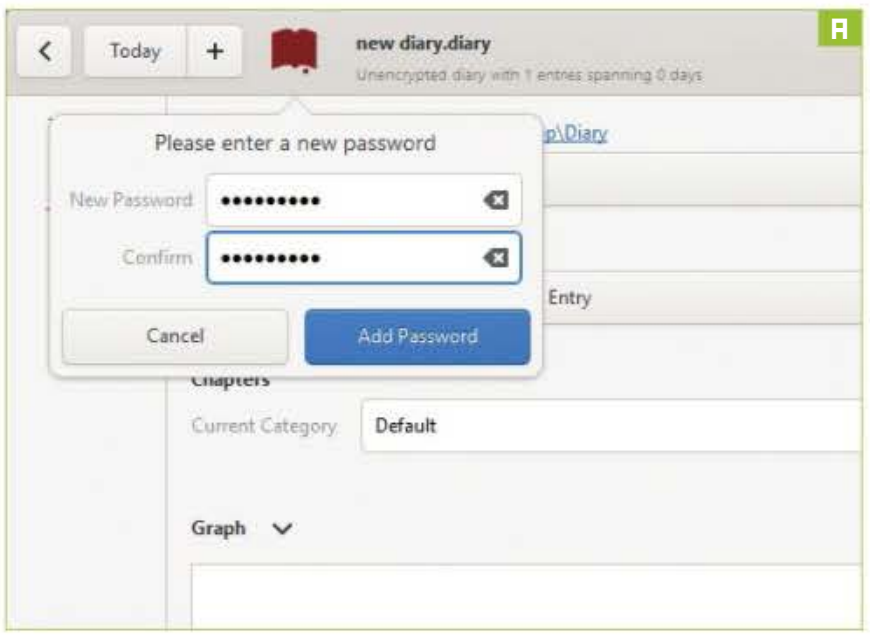
YOU'LL NEED THIS

WINDOWS 10, ANDROID OR A LINUX OS
Copy style of what's needed.

LIFEOGRAPH V1.6.1
http://lifeograph.sourceforge.net.

TIMES ARE TOUGH RIGHT NOW, and making sure you're not overwhelmed by the world around you is imperative to keeping a happy and healthy mind. And what better way to do that than with your own personal diary? Sure, there's nothing quite like putting pen to paper, even in this digital age, but for many of us typing is now far faster and far more efficient for conveying our thoughts down than a pen ever will be.

How do you do it though? Well in this technological age, there's certainly options out there. However, most of those incorporate a blog of some description. One of the biggest weaknesses of blogging is that it's so public. Sure, you can lock down your blog, but unless you're hosting it on your own local server, it can leak online despite your best efforts. And if it's not a private blog? Well you're limited by all those pesky social norms, forcing you into censoring what you might actually be feeling emotionally. Lifeograph (http://lifeograph.sourceforge.net) is designed to provide you with a journal that's offline and—through password-protected encryption—private. It's clean and simple to use, but dig a little deeper into it and you can get even more from it than just its simple text-based scribbles. –**NICK PEERS**



1 FIRST STEPS

After installation, launch the program to find yourself at the main program screen, which going forward will provide you with a list of all recently opened diaries (yes, it's possible to set up and run multiple diaries to keep various aspects of your life separate). The first time it appears, you'll see a handy "If this is your first time with the program, click here to start right away' button to create your first diary file. Choose a suitable location on your hard drive, and provide your choice of filename (with a .diary extension) before clicking "Save".

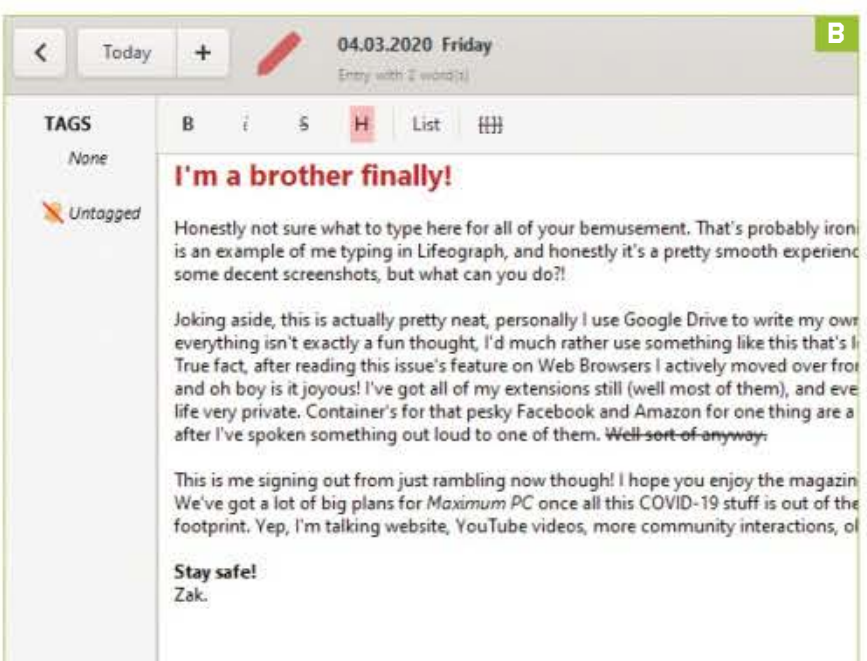
›› First, encrypt your diary for greater security if necessary: click the diary's filename in the right-hand navigation pane to bring up its Properties screen. Next, click the "Edit" button (top left) followed by the diary icon to its right to bring up a pop-up menu. Select "Encrypt", then add a password [**Image A**]. The diary will be encrypted using AES-256, and you'll need to enter the password to open the diary in future. As an extra security measure, Lifeograph logs you out of your diary (while saving it) after 90 seconds of inactivity—look out for the countdown timer popping up and giving you a 10-second warning (click anywhere within Lifeograph to cancel it). You can temporarily disable this by clicking the "v" next to the "Log Out" button and clicking "Disable Auto Logout for This Session". Permanently disable the feature, or change the expiry time, by clicking the burger menu symbol to the left of the "Log Out" button and choosing "Preferences".

›› While you're at the Preferences screen, you can change the date format from the default (YYYY-MMDD). Toggle the formatting toolbar on/off in Diary Entry view, and show a preference for the dark Gtk+ theme.

2 YOUR FIRST DIARY ENTRY

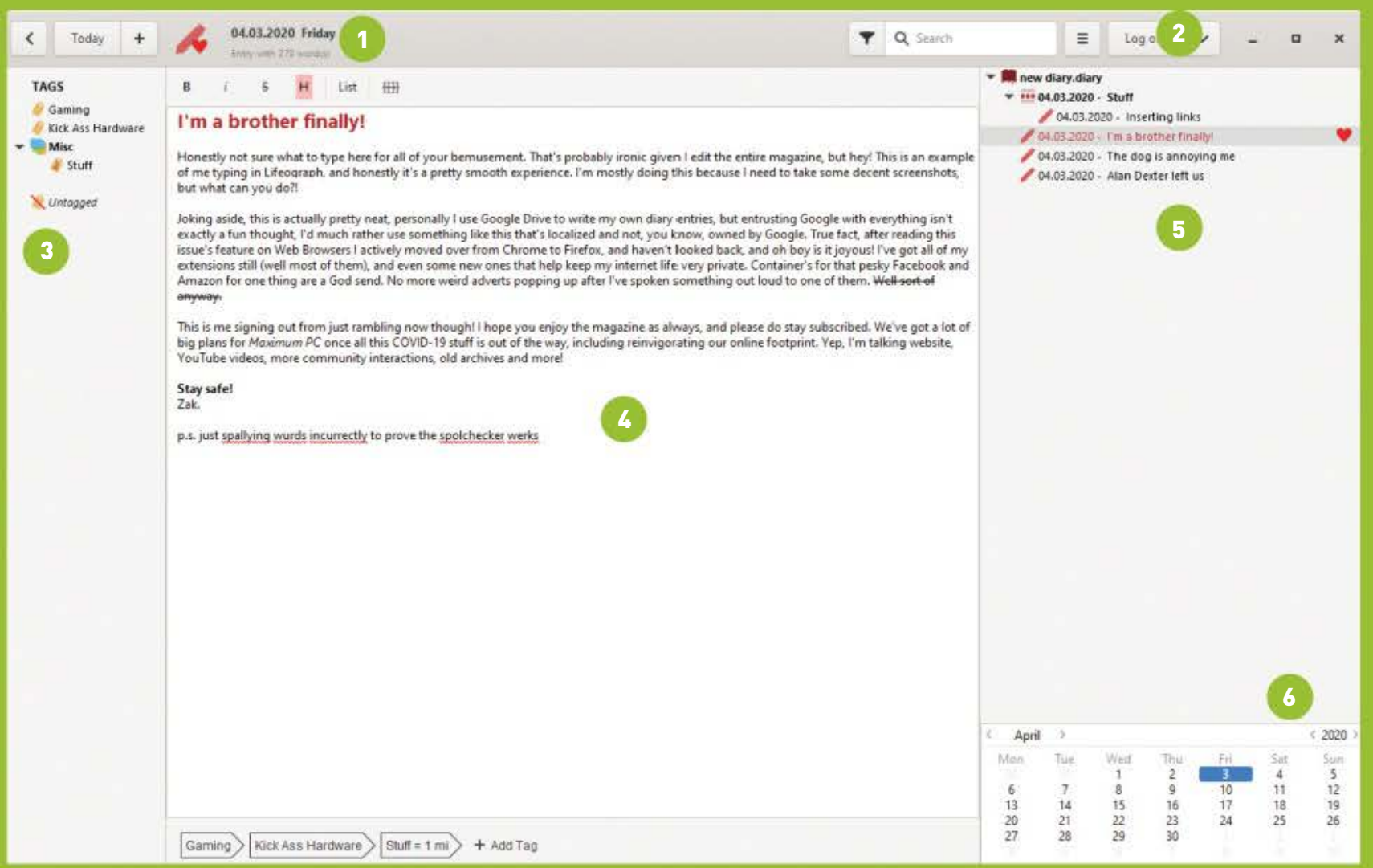
You will see that an empty entry for today has been created. You switched from read-only mode earlier (if not, look for the blue "Edit" button and click it), so you can now start recording your thoughts in your diary. It's as familiar as using a text editor, with added support for limited formatting. Note that your first line will automatically be formatted as header text. Hit Return, and subsequent lines will then default to plain body text.

›› The formatting toolbar reveals support for bold, italics and strike-through text, as well as highlighted


Today
+
04.03.2020 Friday
TAGS
None
Untagged
B
I
S
H
List
I'm a brother finally!
Honestly not sure what to type here for all of your bemusement. That's probably iron
is an example of me typing in Lifeograph, and honestly it's a pretty smooth experienc
some decent screenshots, but what can you do?!
Joking aside, this is actually pretty neat, personally I use Google Drive to write my own
everything isn't exactly a fun thought, I'd much rather use something like this that's l
True fact, after reading this issue's feature on Web Browsers I actively moved over fro
and oh boy is it joyous! I've got all of my extensions still (well most of them), and eve
life very private. Container's for that pesky Facebook and Amazon for one thing are a
after I've spoken something out loud to one of them. Well sort of anyway.
This is me signing out from just rambling now though! I hope you enjoy the magazin
We've got a lot of big plans for Maximum PC once all this COVID-19 stuff is out of the
footprint. Yep, I'm talking website, YouTube videos, more community interactions, ol
Stay safe!
Zak.
B

© LIFEOGRAPH

NAVIGATE LIFEOGRAPH'S INTERFACE


Today
04.03.2020 Friday
1
Search
2
TAGS
Gaming
Kick Ass Hardware
Misc
Stuff
Untagged
3
B
i
S
H
List
I'm a brother finally!
Honestly not sure what to type here for all of your bemusement. That's probably ironic given I edit the entire magazine, but hey! This is an example of me typing in Lifeograph, and honestly it's a pretty smooth experience. I'm mostly doing this because I need to take some decent screenshots, but what can you do?!
Joking aside, this is actually pretty neat, personally I use Google Drive to write my own diary entries, but entrusting Google with everything isn't exactly a fun thought, I'd much rather use something like this that's localized and not, you know, owned by Google. True fact, after reading this issue's feature on Web Browsers I actively moved over from Chrome to Firefox, and haven't looked back, and oh boy is it joyous! I've got all of my extensions still (well most of them), and even some new ones that help keep my internet life very private. Container's for that pesky Facebook and Amazon for one thing are a God send. No more weird adverts popping up after I've spoken something out loud to one of them. Well sort of anyway.
This is me signing out from just rambling now though! I hope you enjoy the magazine as always, and please do stay subscribed. We've got a lot of big plans for Maximum PC once all this COVID-19 stuff is out of the way, including reinvigorating our online footprint. Yep, I'm talking website, YouTube videos, more community interactions, old archives and more!
Stay safe!
Zak.
p.s. just spallying wurds incurrectly to prove the spolchecker werks
4
Gaming
Kick Ass Hardware
Stuff = 1 mi
+ Add Tag
new diary.diary
04.03.2020 - Stuff
04.03.2020 - Inserting links
04.03.2020 - I'm a brother finally!
04.03.2020 - The dog is annoying me
04.03.2020 - Alan Dexter left us
5
6
April
2020
Mon Tue Wed Thu Fri Sat Sun
1 2 3 4 5
6 7 8 9 10 11 12
13 14 15 16 17 18 19
20 21 22 23 24 25 26
27 28 29 30

1 ENTRY TITLE
Click the title to rename it, or click its associated icon to turn it into a to-do item or make it a favorite.

2 SORT DIARY ENTRIES
Click the hamburger menu button to change the sort type (date, size, or last changed) and the order (either ascending or descending).

3 TAGS
Assign these to diary entries to help organize them—click one to edit its properties (including theme).

4 DIARY ENTRY WINDOW
This works like a regular text editor with some clever additional options, including support for markdown formatting and hyperlinks.

5 NAVIGATION PANE
All diary entries and chapters are listed here. Use "Search" or "Filter" to control what's shown by date, keyword, or other.

6 CALENDAR
Use this to navigate by date—days with entries linked to them appear in bold: click once to view, double-click to create a new entry.

text and lists in the form of bullet points or a to-do list [**Image B**]. You can also set up a list by starting a line and pressing Tab followed by your choice of character: asterisk for bullet, plus dash (-), number and full stop (1., 2., and so on).

» There's support for more sophisticated formatting in the form of additional sub-headers, mark-up text, and internal (and external) hyperlinks. Sadly there's no support for images on Windows. However, with Linux your entries can include them, but only as a thumbnail with a link to the original image. The simplest way to do this is to create a new paragraph within your text, then drag the file from "Files" into it, or to copy and paste it from another application

» It's also possible to insert asides in the form of specially formatted comments anywhere in your text (for example, references or explanatory text that doesn't always need to be displayed). This button reveals the mark-up text you need to use—simply enclose your comments within double square brackets [[like so]] and they'll automatically be formatted. Use the "[[]]" button on the formatting toolbar to toggle between hiding or showing comments as required.

3 NO MORE SPILLING MESTAKES

Lifeograph has a built-in spell-checker covering multiple languages. It's disabled by default, but you can manually apply it to the current diary entry by right-clicking and choosing "Spell Checking" followed by your chosen language. Any misspelled words are then highlighted in the usual way—with a red squiggle beneath them. Just right-click the word to reveal suggested alternatives [**Image C**].

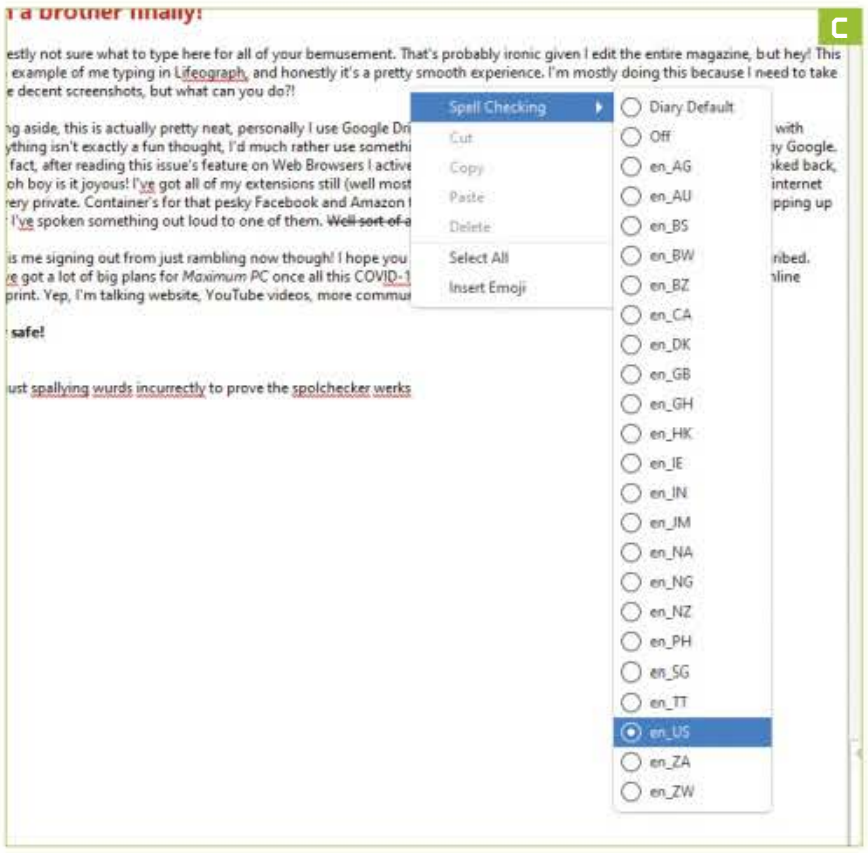
» If you would like to apply spell-checking to the entire diary, switch to its Properties screen (click the diary filename in the navigation pane if you've forgotten how). From here you can set your choice of spell-checker and choose a start-up action, which lets you select the diary entry you want to be displayed when you first open it—the latest entry, the last entry you were viewing, or a specific entry. Beneath this you'll also see a Chapters drop-down menu, which lets you divide your diary into specific segments—we'll look a bit more into that shortly.

BUILD YOUR OWN THEME

Lifeograph enables you to change the look and feel of diary entries using themes to define the color scheme used. These are applied at the tag level: when you select a tag to view its properties you'll see a section devoted to themes. Here you should be able to change the color of selected items, whether it's text in the case of headings and normal text, or the color used for highlighted text, or the background of the entry. You can also change the font size and style too, again by clicking the appropriate option and making your choice from the menu.

Once you've assigned a custom theme to a tag, you can quickly paste it to another one. Select that tag, click the drop-down menu next to "Theme", and choose "Copy From" followed by your desired tag. You'll see a "Reset To Default" option on the "Theme" drop-down menu should you need it.

Any entries that aren't assigned to tags are themed according to the "Untagged" entry, which you can also customize. Themed tags are identifiable by their dotted red outline. If you assign two themed tags to an entry, the post will keep the theme from the original tag. To switch to the other tag's theme, simply click its entry in the bottom pane, and click "Use Theme" from the pop-up menu.



» To return to your previous diary entry, click the back button in the top left-hand corner, or click its entry in the right-hand pane. While you're there, you can change the current diary entry's date by clicking on it at the top of the main window—enter the new date using the same format as the current one.

4 IT'S TAGTASTIC

There are several ways you can introduce layers of organization to your diary to make content quicker to find. One is to favorite individual posts—click the icon to the left of its title and you'll see a heart icon. Click this and you'll see a heart appear over both its icon and next to its entry in the navigation pane [**Image D**].

» Another easy and visible way is to add tags to posts. You'll see the "Add Tag" button in the bottom of the screen. Click this, add your first keyword, and click "Create Tag". Not only is the tag added to this diary entry, but it will appear in the "Tags" list on the left-hand side of the Lifeograph window. Going forward you can simply drag tags from here into the main diary entry pane to add them to the post.

» Click a tag in the left-hand pane, and its properties will pop up. This works in a similar way to other elements, with the ability to quickly rename it by clicking the name at the top. You'll also see an option to assign it a specific category—yet another layer of organization—and also change its type and unit.

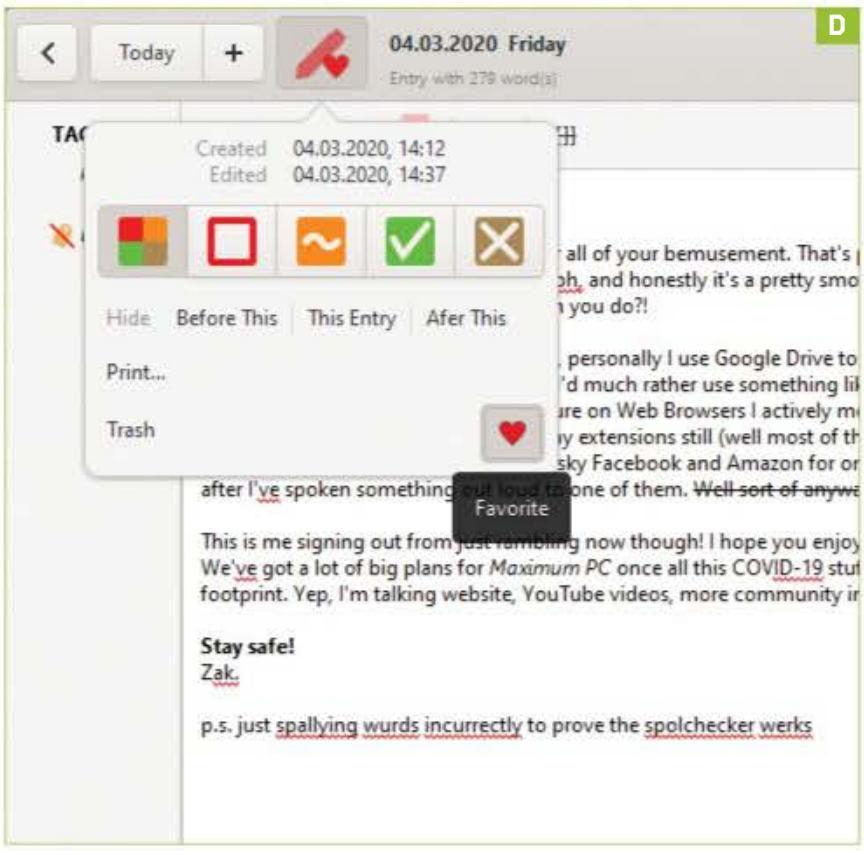
5 CRYING OVER TAGS

This is where things get interesting: the default type of tag is Boolean, which is perfect for simple keywords, but Lifeograph also supports parametric tags, which enable you to add numeric values to tags on an entry-specific basis. There are two types of parametric tag here: cumulative (perfect for totting up your football team's points tally over a season) or average (for monitoring weight over an extended period).

» When creating the tag for the first time, simply enter "TAGNAME = ←VALUE→" and hit Enter. The value should be unitless for now—supported units are kilometers, miles, kilograms, pounds, liters, Celsius/centigrade and Fahrenheit. To assign a unit to the tag, click the "Type & Unit" drop-down menu—you can switch between cumulative and average—and click the "Unitless" drop-down menu to specify your unit. Return to the diary entry and you'll see the unit is now displayed next to the tag.

» Going forward, the tag plus value can be assigned to other diary entries in the usual way—if you drag and drop it, it will automatically be given a value of one. Click the tag to reveal a pop-up menu, where you can change this.

» Return to the tag properties screen over time and you'll see the statistical graph at the bottom update to show potentially useful information. Graphs beneath



Boolean tags simply display the number of entries containing that tag on a month-by-month basis, while those for parametric tags can be used to show the growth in cumulative values over time, or changing averages, depending on the tag type.

» The graph tracks figures on a monthly basis by default, but you can change this to yearly by clicking the drop-down menu next to "Graph". An "Underlay Previous Year" box can be ticked to compare this year with the previous one; also look for a zoom slider with an accompanying horizontal scrollbar for tracking data over an extended period.

6 WORKING WITH CHAPTERS

On one level, Lifeograph can be used purely to record diary entries—multiple entries per day are permitted—and the whole list appears in the right-hand navigation pane, which can be sorted from the burger menu (see the annotation). But you can go further and divide your diary into chapters, then organize (or create) entries to sit within these sub-folders.

» The quickest way to create new chapters is via the main screen. Click the "+" button next to the "Today" button and you'll see a pop-up menu appear, revealing that three types of chapter are supported: by date, by number, or a so-called "free chapter".

» Date chapters work in a slightly different way to the others: you're limited to one per day, and they can be color-coded to identify them when viewing the diary's statistics in graph form.

» Once created, you will then be taken to the chapter title's Properties page in "Edit mode" [**Image E**]. From there you can replace the "New chapter" part of the title by clicking on the chapter title at the top of the screen. Click on the icon that's to the left of its title, and you can assign it a status icon instead of using the four to-do options available elsewhere.

» New diary entries can be created directly from this screen, or you can drag and drop existing entries into the chapter via the right-hand navigation pane in the order you want them to sit. Drag and drop entries into a numbered chapter, and they'll be assigned prefixes—1.1, 1.2, 1.3, and so on—while dragging diary entries into a date chapter will see their date automatically changed to match the chapter.

» Should you wish to delete a chapter, click the chapter icon next to its name—you'll see a "Dismiss" option underneath the to-do boxes. Select this, read the warning (any nested diary entries are moved back to the top level of your diary unless you tick "Also Dismiss The Entries Within" to delete them too), and click "DISMISS!" to remove it.

7 TROUBLESHOOTING

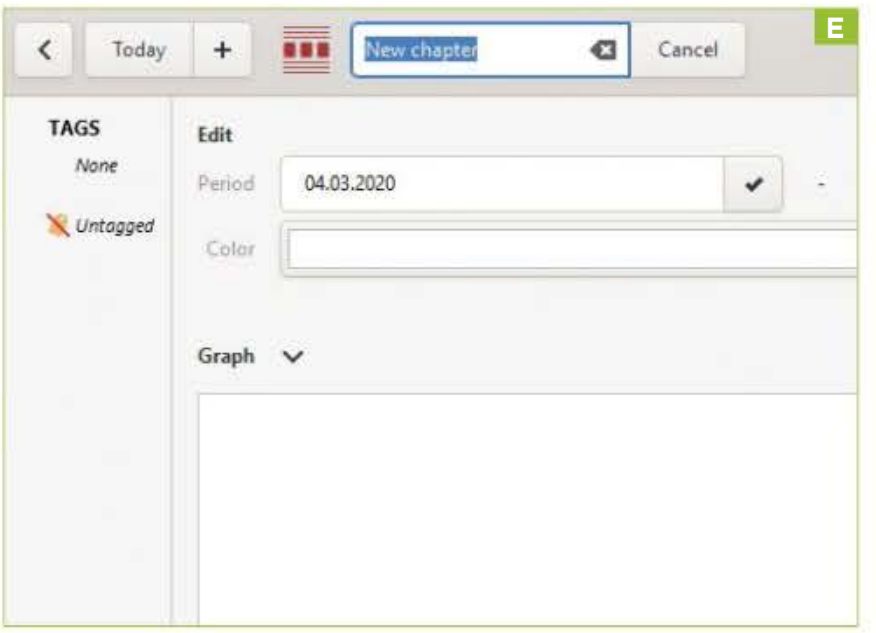
Lifeograph isn't completely bug-free. Sometimes it'll just crash with no rhyme or reason. Unsaved changes made since you last logged out of the diary are stored in a hidden file with a ~LOCK~ file extension. When you reopen the file, these changes should be merged back into the original, enabling you to log out and hopefully delete the file.

» That doesn't always happen, however. Click Edit, and you'll see a warning about the lock file being in place. You'll need to log out, then browse to the directory containing your .diary file. Inside there is the hidden ~LOCK~ file (tick "Show Hidden Files" in "Files" to make it visible). You need to move your main .diary file to another folder, then rename this file with a .diary extension to recover all the changes made since the main file was saved.

8 SHARING YOUR DIARY

There are several ways you can share your entries. Individual ones can be printed by clicking the icon next to the title and choosing "Print". You can also export all or part of your diary as a Lifeograph diary file or plain text. To do this, set up your filter to select only those entries you want to export, then click the diary filename in the navigation pane. Click the diary button at the top of the screen, and you will see an "Export" option. Enter your diary's password if necessary, then choose to export all entries or only the current filtered ones, followed by your desired format, and finally click "Export". If you export your entries in plain text, all markdown formatting marks are preserved.

» You may also wish to access and update your diary on different machines. Lifeograph offers desktop apps for Linux and Windows, plus an Android app that mirrors the desktop version effectively, allowing you to read (and update) your thoughts while you're on the road. One way to do this is to keep your diary file in a shared location—a secure cloud folder, for example—that each client can access as and when required.



SYNC CONTENT BETWEEN DIARIES

Lifeograph enables you to perform a selective merge or sync between two different diary files, choosing exactly what to transfer between them—entries, tags and/or chapters.

Click your diary file's name in the navigation pane to bring up its Properties screen. With "Edit mode" on, click the diary's icon and choose "Synchronize/Merge..." Click the "None" button at the top to select your diary. You may find that leaving "Diary Files" selected as the file type produces no matches, so change this to "All Files" to locate and select the file containing the data you wish to bring across.

By default, all items are set to be added as new entries in the new diary. Click "Scheme" to change the default behavior (you may wish to set "Changed" to "Overwrite" if you're happy to replace existing entries with their corresponding entries from your original diary). You can then select each individual item and click the gray "I" button to set it to ignore, or the "A" button to add it. Flick the "Apply To Similar" switch to "On" and change the status of one item—be it tag category, tag, chapter or entry—to make all entries of the same type change along with it. Click the "Tag Imported Entries" box to create and assign a tag to all imported diary entries. Once you're happy with your selection, click the "Go" button, and the entries should successfully transfer across.

Break Back into Control Panel

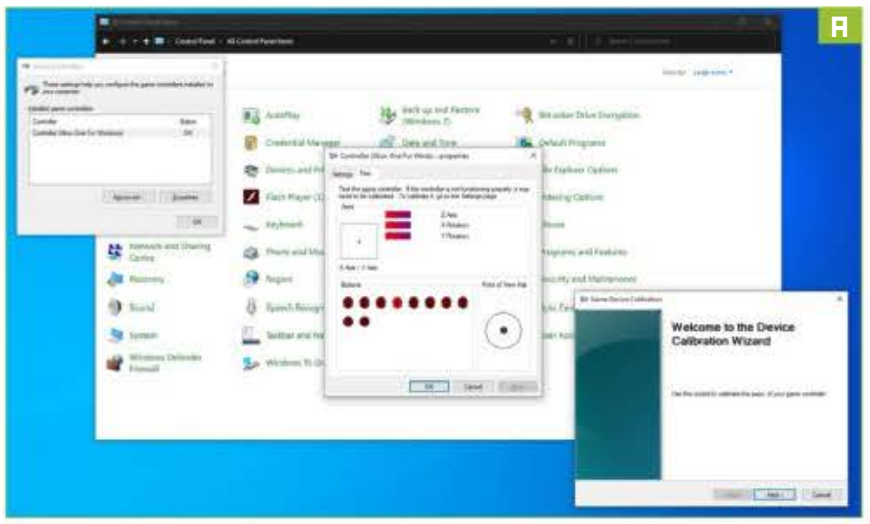
YOU'LL NEED THIS

WINDOWS 10 HOME/PRO
Any version will work.

AHHH THAT ANCIENT AND MYSTICAL Windows Control Panel, it's that one area that should've always remained sacrosanct to the Windows operating system. In fact it's been around in some form or another since 1985 and the launch of Windows 1.0.

In those early editions of Windows, Control Panel was where you'd turn to if you wanted to change all manner of system-related settings. Whether that was hardware tinkering, trying to set up that pesky printer, or configuring a VPN to tunnel into your own home network when out and about, it's been an integral part of the Windows experience since its conception.

With Windows 10, however, Microsoft has attempted to largely replace the Control Panel—for some unknown reason—with the far inferior Settings window. We say "largely" because although Settings enables you to access the vast majority of Windows' options, there are still some that are locked away in Control Panel. With this in mind, it is all the stranger that Microsoft continues to make it increasingly difficult to access this legendary area of Windows with each successive build. It feels as if, over time, Control Panel is slowly fading away into the background, but the truth is it is still there, and still immensely useful—and could well harbor some secrets that you might not even know about. **–MARK WYCIŚLIK-WILSON**



1 FINDING CONTROL PANEL

Microsoft would prefer you to use Settings, so Control Panel is a little buried in the Start menu. You can find it by clicking "Start", and scrolling down to the "Windows System" folder. To save you from all of that scrolling, you can also just click the Start button and type "control panel" to perform a search for it—you just need to click the link that appears at the top of the list of results.

2 SEARCH FOR SETTINGS

There are a huge number of options in Control Panel, and it can be difficult to remember where you should look for something—this is where the search function comes in. Control Panel functions much like a folder within Explorer, so you can search using the search box in the upper right-hand corner of the window, and easily hone in on something.

3 SECRET SEARCH OPTION

Searching can help you discover settings you've never heard of. Try typing "e" into the search box—because the vast majority, if not all, settings names include that letter—and press the Enter key. You'll be presented with a massive list of settings grouped together into categories. You just need to click one to jump straight to that Control Panel applet.

4 SECRET GAME CONTROLLER APPLET

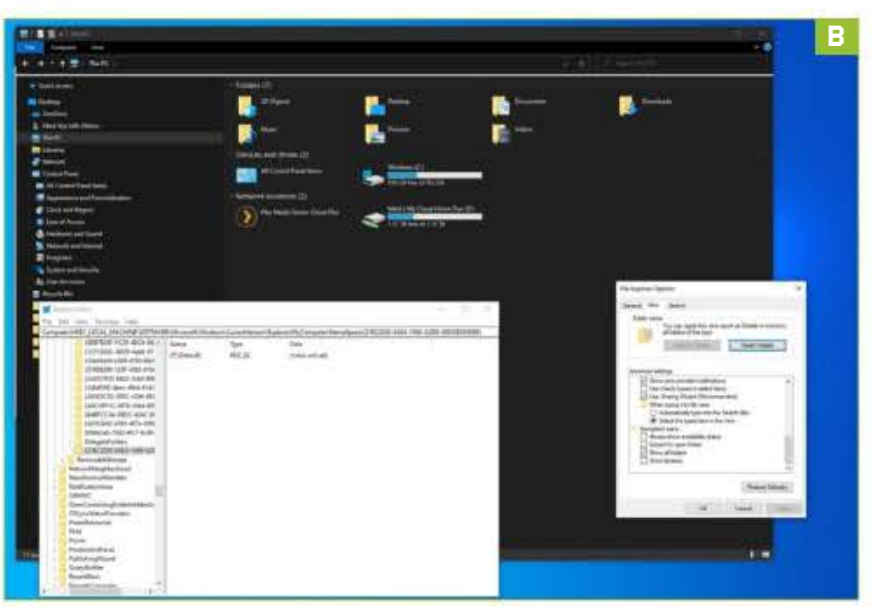
If you're a gamer, you might be surprised to learn that there's a hidden "Game Controllers" applet. Press the Win and R keys to activate the Run dialog, type "joy.cpl", and press Enter. [**Image A**] Select your controller from the list, and click "Properties". On the "Test" tab you can check all of the buttons work, while on the "Settings" tab you can access the calibration wizard.

5 ACCESS GOD MODE

There is a hidden mode for Control Panel that has become known as "god mode". All it takes is the creation of a specially named folder. Right-click on the desktop, and select "New" then "Folder", before naming it "GodMode.{ED7BA470-8E54-465E-825C99712043E01C}"—you can replace "GodMode" with anything you like.

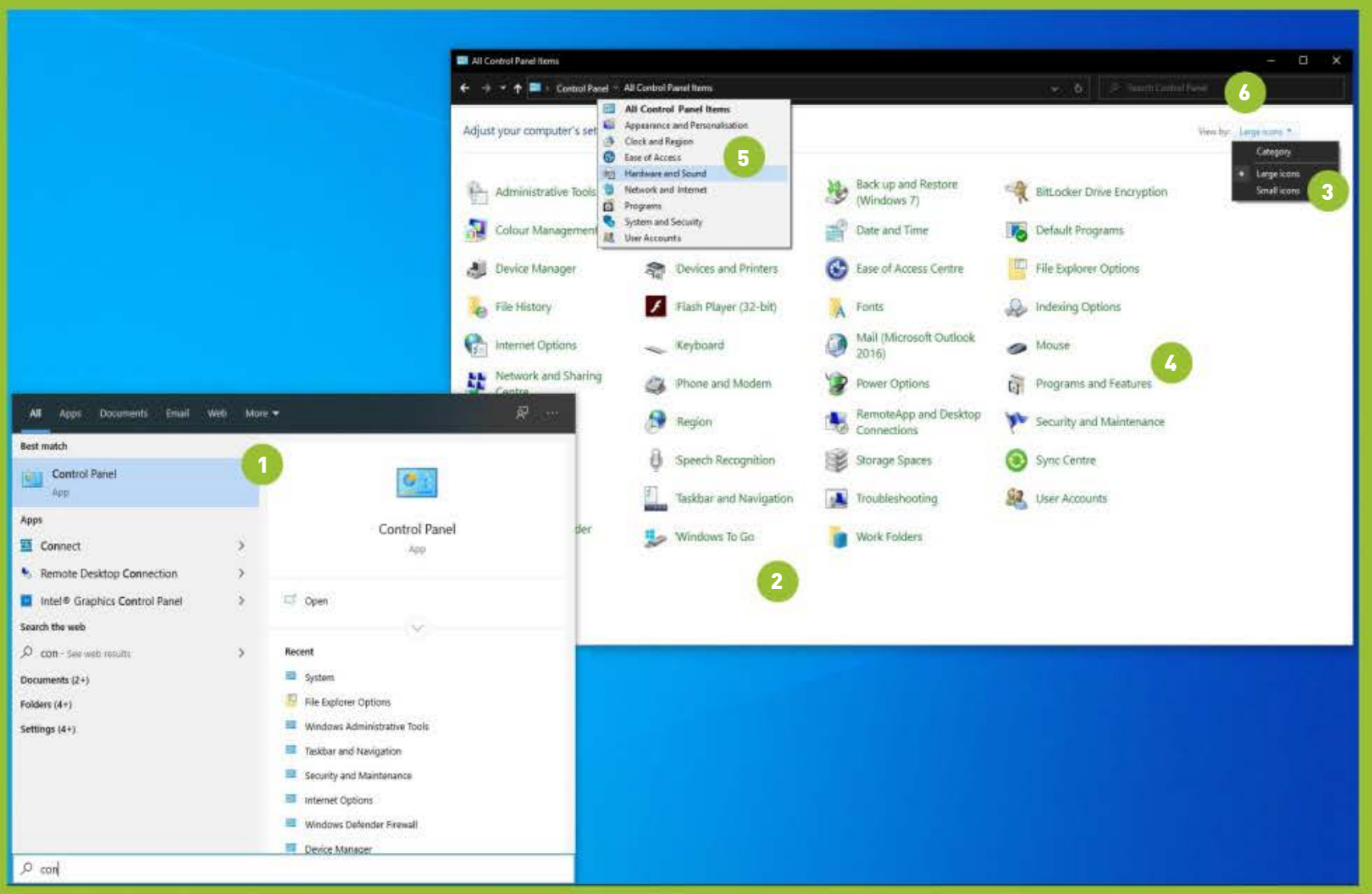
6 OTHER HIDDEN CONTROL PANEL SHORTCUTS

Try creating these folders: "Application Connections. {241D7C96-F8BF-4F85-B01F-E2B043341A4B}"; "Default Programs. {17cd9488-



© MICROSOFT

THE CONTROL PANEL INTERFACE



1. START MENU
Searching the Start menu for Control Panel is perhaps the easiest way to find it to start with.

2. THE PANEL
Each icon in Control Panel represents an applet that can be used to change numerous system settings.

3. VIEW MENU
You can view Control Panel in different ways: all the applets at once, or grouping them by type of setting.

4. APPLETS
Some applets open within Control Panel itself, while others will open in separate dialog windows.

5. CATEGORIES
Whatever view you choose, you can browse Control Panel in Category mode by clicking the arrow in the address bar.

6. PANEL SEARCH
A quick and easy way to jump to a particular setting in Control Panel is to search for it using the search box.

1228-4b2f-88ce-4298e93e0966}"; "Firewall and Security {4026492F-2F69-46B8-B9BF-5654FC07E423}"; "Icons And Notifications.{05d7b0f4-2121-4eff-bf6b-ed3f69b894d9}"; "Programs and Features.{15eae92e-f17a-4431-9f28-805e482dafd4}".

7 BOOST SYSTEM PERFORMANCE

You can boost your computer's performance by disabling some animations and effects. Open "System" in Control Panel and click "Advanced system settings" to the left. On the "Advanced" tab, click the first "Settings" buttons under the "Performance" heading, then select the "Adjust for best performance" option—or manually specify what to disable.

8 ADD CONTROL PANEL TO FILE EXPLORER

You can add a Control Panel link to This PC via the Registry Editor. [**Image B**] Press the Win and R keys, type "regedit", press the Enter key, and navigate to "HKEY_LOCAL_MACHINE\SOFTWARE\ Microsoft\Windows\CurrentVersion\ Explorer\MyComputer\ NameSpace". Create a new key called "{21EC2020-3AEA-1069- A2DD-08002B30309D}".

9 CUSTOMIZE DESKTOP ICONS

A slightly hidden Control Panel applet lets you choose which icons should appear on your desktop, including adding a Control Panel shortcut. Right-click on the desktop and select "Personalize", before moving to the "Themes" section. Click the "Desktop icon settings" link on the right, then use the tick boxes to choose which icons—This PC, Recycle Bin, etc.—should be displayed.

10 HELPFUL SHORTCUTS (& SCREENSAVERS!)

If you find that you use some Control Panel applets relatively frequently, you can create helpful shortcuts to jump straight to them from either the desktop or Start menu. Right-click on an applet, and select "Pin to Start" to add it to the Start menu, or "Create shortcut" to add it to the desktop instead. You can also access a hidden screensaver applet by creating a desktop shortcut that points to "rundll32.exe shell32.dll,Control_RunDLL desk.cpl,,1".

Benchmark your CPU like Maximum PC

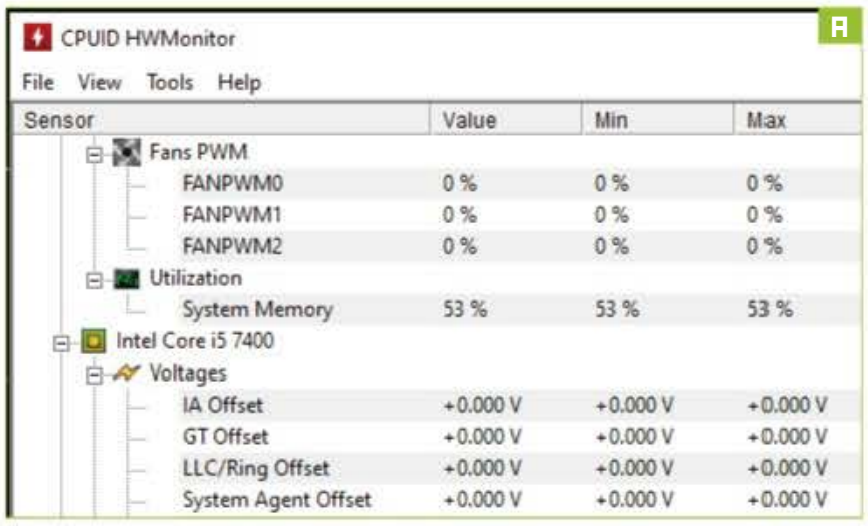
YOU'LL NEED THIS

PC OR LAPTOP
(preferably with a CPU).
A screen, mouse, keyboard and Internet connection.
An ad-blocker, or superhuman tolerance for ersatz download buttons.

REGULAR READERS will know that benchmarking is a big deal in the *Maximum PC* office (or, as we produce this issue during lockdown, the respective homes of the *Maximum PC* team). Benchmarking can be an arduous process, full of frustration and confusion. Why won't this test run? Why is this result so low? The sheer amount of different benchmarks is no help; hunt for figures for a specific component and you might end up with dozens of meaningless results.

But never fear; we're here to show you how we do things, starting with how exactly we test CPUs. If you're curious about the performance of your system, or you're assembling a fresh build and want to show off your specs, then benchmarking is the way to do it. In this tutorial, we're going to explain each of the tests we use to evaluate the performance of processors.

It's worth noting that this guide is specific to Windows systems; we typically install Windows 10 on every system we build or test. We're also not going to get stuck into gaming benchmarks here, since they generally require ownership of the game and are usually simple to run, with a standard average frame-rate result. –**CHRISTIAN GUYTON**


CPUID HWMonitor
File View Tools Help
Sensor Value Min Max
Fans PWM
FANPWM0 0 % 0 % 0 %
FANPWM1 0 % 0 % 0 %
FANPWM2 0 % 0 % 0 %
Utilization
System Memory 53 % 53 % 53 %
Intel Core i5 7400
Voltages
IA Offset +0.000 V +0.000 V +0.000 V
GT Offset +0.000 V +0.000 V +0.000 V
LLC/Ring Offset +0.000 V +0.000 V +0.000 V
System Agent Offset +0.000 V +0.000 V +0.000 V

1 THE SIMPLE STUFF

Plenty of the CPU benchmarking software we run can be downloaded for free as a trial version, which is ideal for testing out your own system at home. You may, however, want to activate an ad-blocker before downloading these; some freeware sites are rife with fake download buttons and intrusive ads. First up is AIDA64, a system-information tool, the Extreme edition of which can be downloaded with a 30-day free trial. We primarily use AIDA64 Extreme for benchmarking the system memory and CPU together, as it enables you to view real-time latency for the overall RAM and individual CPU cache speeds.

›› AIDA64 also provides a staggering amount of general system information, as well as benchmarks for memory, drives and GPUs. The latter includes integrated graphics tests, an ideal way to check the performance of the IGPU. The program even includes direct links to Intel's ARK website, which contains just about every bit of information about Intel processors. It's worth noting, though, that the trial version of the software does limit some features and test results.

2 ON YOUR MARK

Another program with a free trial (although we'd recommend buying the full version if you're building or tweaking a system and want to run multiple tests) is PCMark—versions 8 and 10 are commonly used. Both are relatively straightforward system-benchmarking programs, putting your machine through its paces and spitting out a number at the end. PCMark 8's trial version is slightly more comprehensive, including Creative and Work preset benchmarks, as well as the standard test.

›› The result you get from PCMark's benchmarks isn't a 'real' figure as such. It doesn't provide any specific data on how your PC is performing, but instead gives an indexed number that's meant to be compared online. https://benchmarks.ul.com keeps track of assorted scores for CPUs, and the paid version of the program can record and compare multiple scores. Once you've run the benchmark on your system, you can easily check if it's performing on par with similar PCs. There's even leaderboards, where experienced system-tweakers can show off how far they've been able to push their processors. You can use HWMonitor [**Image A**] in the background (see boxout "Keeping Score'") to check how hot your processor gets during benchmarks.

© CPUID

FULL THROTTLE

If you're overclocking your CPU, benchmarking and stress-testing software is vital. Prime95 offers a free way to stress-test your CPU; for our CPU reviews, we use its "torture test" option to max out the processor as an overclock-stability check. Leaving Prime95 running for a few minutes will let you reach the effective maximum running temperature. If that temperature exceeds safe levels, however, your processor will throttle and eventually trigger a system shutdown to avoid damage to the chip.

We recommend using Prime95 in conjunction with HWMonitor to keep an eye on core temperatures in real time. The chip's max operating temperature can be found online from AMD or Intel; this way, you can see if your CPU is approaching dangerous heat levels, and shut down Prime95 before your system crashes. If your chip overheats; lower the voltage or target frequency and try, try again. Eventually Prime95 should run indefinitely without the processor rising above safe temperatures.

B
C:\Windows\System32\cmd.exe
x264 HD Benchmark v5.0.1
by graysky
updated by Adrian Wong
and Dashken
www.techarp.com
This benchmark performs a high-quality
2-pass encode of a Full HD MPEG2
1920 x 1080 @ 20,000 kbps source
using 32-bit or 64-bit x264 encoders.
Please enter the name you'd like to give the results text file.
For example, you might want to use your current CPU settings as the file name.
e.g. the CPU multiplier and FSB (like 333x9 for example): 123
The results will be written to x264_1080p-123.rtf
This new benchmark uses the latest x264 r2197 32-bit and 64-bit encoders so
it will better reflect the performance of multi-core processors. It will

3 BLENDER RENDER

Next up is the Blender benchmark. For the uninitiated, Blender is an excellent piece of open-source 3D modeling software, available for free at www.blender.org. However, it can also be used as a 3D-rendering benchmark for your CPU or GPU, using one of the ready-made render tests available under "demo files" on the Blender website. We use the "Car Demo'", a detailed 3D model of an orange BMW, with version 2.82 of Blender. The process is relatively simple; install Blender and download the demo file, then open it in Blender and begin the render process using the toolbar at the top of the screen. The total time taken to render the image is the point of comparison here; the faster the better. We convert this into a pixels per second, or pps, figure by dividing it by the total pixel count (i.e. the image resolution). The demo file download includes two files—one for CPU testing and another for GPUs; so check you're using the right one!

›› Another free rendering benchmark we use is Cinebench. As you might have guessed from the name, this is a dedicated piece of CPU-benchmarking software that uses your processor to perform a high-intensity render test, and assign you a score that can then be compared against other processors. Cinebench will even save benchmark scores in-app, making it an ideal before-and-after test if you're changing your processor. We use Cinebench R15, although the R20 version is also available for free. This benchmark is as simple as it comes, giving you a nice "Run" button in the upper left corner of the screen. This will run the all-cores version of the test; under File → Advanced Benchmark, you can find single-core and OpenGL tests as well.

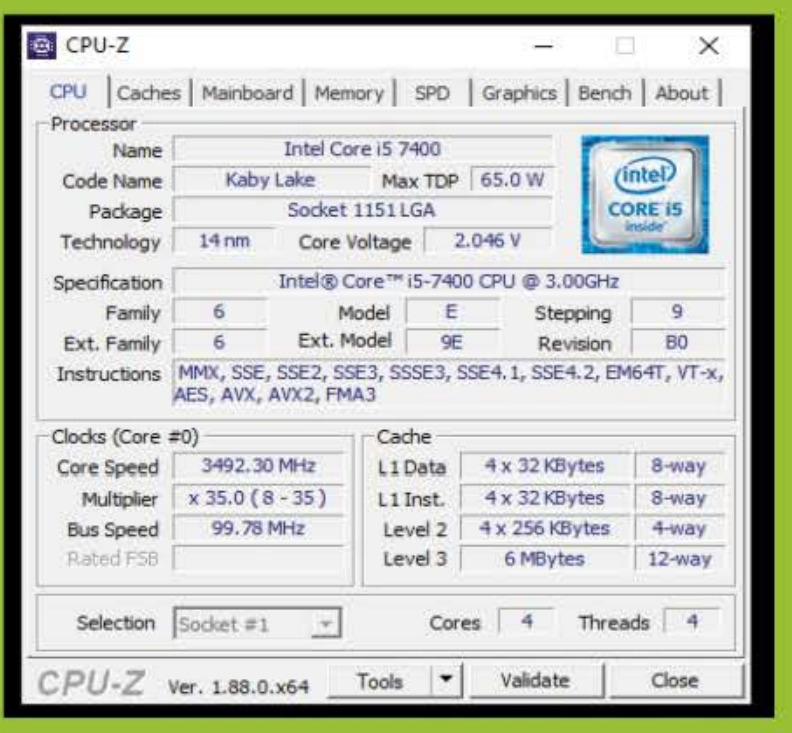
4 IT'S COMPLICATED

We've kept the more complex stuff for last. POV-Ray is a ray-tracing program that generates an image, allowing you to calculate another pps statistic for your processor. POV-Ray can be downloaded for free at www.povray.org, and also features a page detailing how to benchmark with the program. The standard download includes a test file, imaginatively named "benchmark.pov", which provides a common environment for CPU tests so that they can be compared online. To run it in POV-Ray 3.7 for Windows, find the benchmark command in the Render Menu in-app, or use the /BENCHMARK command-line option.

›› Perhaps the most troublesome piece of software we use to test CPUs is the x264 video-encoding benchmark [**Image B**], created by Malaysian tech news website Tech ARP. Tech ARP also offers a handful of other CPU tests. It can be a struggle to set up, as it requires two specific pieces of matched software; the benchmark program itself, and a secondary install called AviSynth; a scripting language designed for video-editing tasks.

›› Once you've downloaded the x264 benchmark, you should have a "run" VBScript file. Run that as administrator, and it will open a text box redirecting you to an online download source for AviSynth on https://sourceforge.net. Don't just hit download; x264 will tell you which version of AviSynth you need, in our case 2.5.8. You can find the different versions under "files" on the webpage. Once the correct version of AviSynth is installed, you'll be able to run the x264 benchmark by reloading the text box. All you need to do is name the test (we would recommend naming it after your CPU), and select the 64-bit version of the benchmark.

›› This benchmark can take a very long time to run—especially on older systems—so be patient with it. Ultimately, it'll give you an average frames-per-second figure that you can compare with other users. And that's it! You have now learned everything you need to know to benchmark your CPU just like us. If it takes your fancy, bash your CPU with a final stress test using Prime95, a free "torture testing" program to check that your CPU isn't overheating or throttling. Now go forth, and find out exactly how good your system is.



KEEPING SCORE

We run a wide variety of tests on CPUs, using more software than we mention in our benchmarking tables. There are two pieces of non-benchmarking software we'd advise downloading; CPU-Z and HWMonitor. Both programs are freeware available from CPUID online, with a simple, ad-free download and setup. CPU-Z provides detailed system information, useful for checking what components are inside a system, while HWMonitor gives you live numbers for a wide variety of stats, from individual core clocks to component temperatures.

The latter program is vital for CPU testing, since min-max tracking enables you to check the peak temperatures your processor hits while you're running other benchmarks—particularly useful for keeping an eye on your CPU when stress-testing with a manual overclock. It can also be invaluable for identifying problem spots; for example, if one CPU core is being over or under-utilised, or if your motherboard temperatures are causing your CPU to throttle. HWMonitor's own CPU usage is very low, so you can leave it running while you perform other tests.

© TECHARP, CPUID

BUILD IT

ZAK STOREY, EDITOR

Purple Haze

We take a look at building the perfect 1440p gaming PC

LENGTH OF TIME: **1-2 HOURS**

LEVEL OF DIFFICULTY: **EASY**

THE CONCEPT

WHEN A NEW COOLER comes out from a manufacturer, it's not often met with much fanfare. These launches, especially in the tech journalism world, happen frequently, and usually only warrant a solitary news post on the likes of Tom's Hardware. Even then they're not likely to garner much in the way of traffic. However, when it comes to NZXT, the company has a bit of a reputation for breaking the rules on what we've come to expect from new product launches. You can see this in its cases. Go back to 2010, and its chassis stack was fairly mediocre. Fast forward a few years, and you get innovations like the S510 Elite, the Manta, the H700 series, to the point where the company has dramatically ascended through the ranks to become a top-tier brand.

Perhaps even more impressive than its cases is the company's cooler design, specifically its Kraken series AIOs. The first gen was very much like the rest of the Asetek AIOs out there—pretty mediocre, some light branding, and a bit of RGB. The second gen came with its own infinity mirror and some stellar lighting effects thanks to NZXT's own CAM software suite, and that was it. In 2019, though, we witnessed the launch of its third-gen Kraken-series coolers, most notably the new Z range. These flagship coolers come with one heck of a premium price point, but also with a fully integrated 2.36-inch LCD digital display.

In fact, it's such an impressive part that we decided to theme an entire build around it. So the task here was simple; combine a butt-load of NZXT parts with a $2000(ish) budget, and aim to hit that 60fps sweet spot at 1440p.

BEST LAID PLANS...

... OF MICE AND MEN often go awry. When we originally set out to do this build we wanted to see what we could do with the Nvidia GeForce RTX 2070—not the Super variant but the standard 70 version. Pairing it with a Ryzen 5 3600X seemed like a good mid-range choice, and as most of our testing is done with Intel processors with GPUs, this pairing made for an interesting case study. The logic behind picking the standard 2070 was that it should, by all visible measures, be considerably cheaper than the RTX 2070 Super, as it packs about 10 to 15 percent less performance overall and has been out for far longer.

We reached out to Gigabyte to request a GPU, went ahead and built the entire system, and photographed it all, only to then realize that RTX 2070 was coming in at nearly $650—that's $150 more than the reference Founder's Edition RTX 2070 Super. We fell prey to that old adage—never assume, because it makes an a... Well you know the rest. Anyway, we can only guess that this price jump is down to a lack of stock or Nvidia phasing the original RTX cards out of existence. So we went back to the drawing board, rebooked photography, and grabbed that 2070 Super instead. That's not necessarily a bad thing—the Founder's Edition is still a classy card, and it complements this build quite well.

As for other components, this rig was all about style and showcasing that stellar cooler. To that end we opted to take NZXT up on its offer of an H510 Elite case too. Its crisp clean glass panels and solid internal design makes building a mid-range system within it fairly easy, and it looks kick-ass to boot. On top of that, we threw in a PCIe 4.0 M.2 SSD from Corsair, 32GB of G.Skill Trident Z Neo memory for some more RGB elements, and left it at that.

INGREDIENTS

PART		STREET PRICE
Case	NZXT H510 Elite	$150
Motherboard	MSI MEG X570 Unify	$300
CPU	AMD Ryzen 5 3600X	$200
GPU	Nvidia GeForce RTX 2070 Super	$500
Memory	32GB (4x8GB) G.Skill Trident Z Neo @ 3600	$241
PSU	750W NZXT C750 Modular 80+ Gold	$120
Storage 1	500GB Corsair Force MP600 M.2 PCIe 4.0 SSD	$120
Storage 2	1TB Crucial P1 M.2 PCIe 3.0 SSD	$110
CPU Cooler	NZXT Kraken Z63 280mm AIO	$250
140mm Fans	1x NZXT Aer RGB 2	$28
OS	Windows 10 Home 64-bit	$100
Total		$2,119

1 CASE UNBOXED

WE'VE SEEN A LOT of striking case launches over the last few years, and the NZXT H510 Elite is up there with the best of them. Although it doesn't have the airflow grunt of some of its competitors, there's no arguing with the fact the style it exudes from those tempered-glass side panels, integrated with RGB fans, is impressive.

Straight out of the box, it's a fairly clean affair. There's not too much we're going to have to adjust at first glance. The main issue is our rear-most fan, being of the non-RGB variety. That really doesn't make a whole lot of sense, especially given how you've got those two Aer RGB 2 fans in the front anyway. We know it's to lower costs, but this is a premium chassis with a premium price point already, so just throw in the extra rear fan NZXT.

2 HDD CADDY REMOVED

THERE'S BEEN A NUMBER of hardware changes that's made system-building easier over the years, but none as effective as the rise of M.2 drives. Replacing the 3.5-inch and 2.5-inch form factors, if your motherboard has the slots for them, you can build an entire system without a hard drive in sight, which means fewer cables. There's now a range of fairly affordable SATA and PCIe drives available in the form factor too. Your best bet? 500GB PCIe 4.0 drive for your OS, 1-2TB PCIe 3.0 drive for additional storage

Back to the case, and getting rid of the hard drive caddy is easy. Remove the four Phillips screws from the bottom of the chassis, plus the one attaching it to the motherboard tray, and you can slide the caddy out.

3 STANDOFF PREP

NOW THOSE ARE SOME meaty standoff screws for the cooler, that's for sure. We've taken the opportunity to fit them before the motherboard goes in the chassis here. It just makes things easier. Most cases nowadays support large enough motherboard tray cutouts that you can do this inside, but it can be annoying, so it's best to do it outside of the chassis.

MSI's Unify motherboard is an area where we splurged a bit too much, perhaps. It's a sleek black board, with no RGB, and a ton of connectivity on top, but it's not the prettiest motherboard. It doesn't have quite the same style as some of Gigabyte or Asus's offerings.

4 MOBO INSTALL

WITH THE STANDOFFS prepared and the Ryzen 5 3600X in place, we've gone ahead and installed the motherboard into the system. This typically should be your first step—even with liquid-cooling builds, it's almost always the motherboard that goes in at the beginning. Then you can start looking at cable runs and where to install other hardware. It's a bit of a tight fit in the H510 Elite, but nothing really too worrying. If you do have trouble, you can remove that cable bar temporarily and reinstall it after the motherboard is in position. It's also handy if you're trying to route troublesome cables.

Here we're also installing the M.2 drives underneath the two heatsinks on the motherboard, placing the Corsair Force MP600 at the top.

7 SECURING THE BLOCK

WITH THE RADIATOR BRACKET reinstalled and the fan cables carefully threaded through into the rear of the case, it's time to install the block itself, and it is seriously big. That's not that surprising really. You've got that two-inch screen, a pump, a water block, a tiny reservoir, and the componentry to display all the digital statistics.

It's worth noting, when installing your waterblocks, to always double-check that the tubing won't come into contact with your memory DIMMs. If they do, you can get around it by moving the memory to the two alternative channels, or in the case of having four sticks like our build. We recommend that you install those first, then install the CPU block afterwards. It'll put some pressure on the top of the stick, but otherwise you should be fine.

8 INTERNAL I/O

WITH THAT OUT OF THE WAY we can begin to install the front panel headers and necessary USB headers onto the motherboard. The H510 Elite comes with USB Type C, as well as USB 3.0 headers for its I/O. On top of that you'll also need to install the two USB 2.0 internal headers—one for the Kraken Z, and the other for NZXT's CAM fan and RGB controller.

We're even including the HD audio passthrough on the far left there. That's not something we typically recommend you use. More often than not, you'll find case manufacturers skimp out on the insulation for the cable, and audio quality suffers in comparison to just plugging your audio hardware into the rear of the motherboard.

5 CABLE MANAGEMENT PREP

NZXT HAS ALWAYS done well with cable management in the rear of its cases. You can see the dedicated channels designed to help route that ATX cable to where it needs to go, the channels at the top of the motherboard tray to direct fan cables to the NZXT CAM controller, and the Velcro straps littered around too. You can also see just how much space we get by removing that hard drive caddy from the bottom of the chassis. That's a big deal, especially with non-modular power supplies, but even with modular ones you'll often have excess cable. There's two more SSD caddies in the back as well.

With NZXT's cable management you can remove all of these parts—the cable routing, the SSD caddies, everything—by removing the Phillips head screws.

6 INSTALLING THE KRAKEN

THE H510 ELITE FEATURES a front-mounted radiator bracket. It's removable from inside the chassis. The reason for this is that you can't actually remove the front tempered-glass panel. So instead you remove the bracket, then install the radiator with the fans attached on the interior side of the bracket. This'll give you plenty of airflow. Along the rear side panel, there's perforations cut out, running about an inch thick down the front of it, to provide ample access to air.

One thing that does disappoint us is that NZXT hasn't found a solution for driving high static pressure with its Aer fans just yet. These 140mm variants only provide up to 1.52mm-H20 at full load—far less than the likes of Corsair's ML Pros or Noctua's NF-F12s.

9 NZXT'S C750 PSU

WE'RE TRYING OUT one of NZXT's C750 PSUs for this build. It's a newly released budget power supply, comes in at around $120, and it features a modular interface and fairly impressive cable sleeving. It's not individual sleeving, but it still looks very clean.

750W is more than enough for any modern-day system. In fact this is probably enough to actually run two RTX 2080s in SLI if you wanted to.

10 FAN WOES

WE RECEIVED an additional Aer fan to install into the H510 Elite, just to boost the internal lighting a bit and exhaust hot air through the roof. It works well, but one thing to note is that it's a bit finicky with some motherboards. To get it installed we have to fit all of the top cables first, including the CPU power, and then gently force the fan into position to line its mounting holes up with the case itself. Once that'sdone, it is simply a case of plugging it into the NZXT CAM controller, so we can take advantage of all of that RGB.

You'll notice that we're installing the G.Skill Trident Z NEO memory as well. That will add more pop to the overall build, and it is considerably brighter than the first edition RGB memory G.Skill released back in 2016.

11 GPU INSTALLATION

AND HERE WE HAVE the RTX 2070 in all its glory. Installation is a fairly seamless experience. Simply remove the retention bracket that secures the expansion slots (two thumbscrews do the trick), then remove the covers you need to, slot the card in, secure it with those same screws, and you're good to go.

We have two different options in how to install the PCIe power for this one. The most obvious route is to go through the cable cutout in the floor of the PSU cover, and then run straight up. We're taking the second option. It's a bit "old school", but we've decided to run the cable by the side of the cable tidy bar, and tuck it between the two. This way it stays tucked out of the way and is less obvious than running straight up to the graphics card.

12 DISPLAY FOR DAYS

AND THERE WE HAVE IT, our complete build. With a quick install of Windows 10 and some RGB software installation, we have this rig running in a nice purple-and-white gradient effect. The CAM software is fairly intuitive, with a responsive UI that works well together. You get a whole swathe of different presets to use with the Kraken Z's display, from GIFs to varying temperature-monitoring setups. You can also do graphics card monitoring, as well as a few other system components. We particularly like how these settings aren't locked to colors either, so if you want to set it to go from white to purple, you can do.

You can spot the G.Skill memory in the background, showcasing its smooth RGB gradient. It looks cleaner than the older Trident Z kits when illuminated. You do need to control that with G.Skill's own software suite though, rather than through motherboard control.

13 ACHILLES' HEEL?

THERE'S NO DENYING that the Aer RGB fans look stellar with those light-diffusing rings running around them, but they are the biggest potential Achilles' heel to this whole build. That lack of static pressure could be a game-ruiner, especially with the seasons getting hotter. If you've not got air-con you might be in for a world of hurt.

If you're looking for an alternative fan that has more static pressure grunt but without losing some of that RGB class, we'd recommend that you take a look at EKWB's latest Vardar X3M fans. They're only available in 120mm variants at the moment, but they still feature an epic level of RGB pizazz, and better yet can pump out an impressive 2.75mm H2O under full load.

14 BUILD COMPLETE

NVIDIA'S LATEST GEFORCE RTX series of cards gets a lot of flack for its new cooler design. While it is true that those twin open-air fans aren't quite as good in confined spaces as a blower-style cooler is, there's something to be said for the overall aesthetic appeal. We particularly enjoy how the purple light diffused by the various RGB components in this build glints off of the sharp edges of the card itself.

So yeah, perhaps it's not the best GPU for a tight, confined ITX chassis, but if you can supply it with enough airflow throughout a case, the design performs exceptionally well.

1 **The radiator bracket here can be a bit finicky to get to sit right once an AIO is installed on top of it. It took a few attempts, and we had to remove the cable bar.**

2 **Here you can see a bit better why we decided to run the PCIe power cable from the right as opposed to just straight up.**

3 **MSI's X570 Unify motherboard comes with its I/O shield built in. All you need to do is line the mobo up with the standoffs and secure it in place.**

4 **This top 120mm fan was by far the most troublesome part of the build. It's incredibly tight up there with the cables.**

PURPLE PASSION

AND THERE YOU HAVE IT. We went into this with the aim of building something that could look the part as well as be an impressive performer—and without embarking on a massive liquid-cooled project. This is something that anyone could put together if they have the budget. With the Kraken Z63 at its core, this build shines. The purple-to-white gradient works really well.

The build process was fairly seamless. The H510 Elite is a fantastic case and looks impeccable. It has some caveats that we're not super happy with, the big one being the fan mounts for the top-mounted exhaust, but other than that there's not a lot to complain about. This product area in NZXT's domain has always been a fantastic mid-range option for those looking for a stylish case that's at home in gaming as much as it is in a clean and professional environment, and NZXT has really delivered.

But did we achieve what we set out to do? The short answer is: yes, absolutely. That Nvidia GeForce RTX 2070 Super, combined with 32GB of high-spec memory and AMD Ryzen 5 3600X, dominates at 1440p and below, and it's not half bad at 4K either. We saw frame rates of 51fps in *Assassin's Creed Odyssey*, 83fps in *Middle Earth: Shadow of War*, and 71fps in *Total War: Warhammer II*. Outside of *Odyssey*, every one of those titles is above the 60fps mark. Take it to 4K, and you'll net 38fps in *Odyssey*, 54fps in *Shadow of War*, and 39fps in *Warhammer*, all of which are respectable there too.

As for system benchmarks, in CineBench R15 it scored a decent 1,630 points in multi, and 203 in the single-core test. We're comparing it below to last issue's cover build, the Pink Pariah, which goes to show how impressive the generational performance jump has been for AMD and Nvidia. The fact that the RTX 2070 Super is outperforming a standard 2080, in combination with a third-gen Ryzen, shows the difference that CPU architecture has made. It's also a lot cheaper than our liquid-cooled attempt too.

We've also had no temperature problems at the time of writing. There's even room right now to give it a bit of an overclock.

So is there anything we'd change? Outside of those fans we mentioned, the other problem areas for us are the motherboard and power supply. That mobo just doesn't look the part, and it's hardly cheap either. ASRock's X570 Extreme4, or the Asus ROG Strix X570-F Gaming, would suit better and drop the price, without losing M.2 SSD capacity. We could then take the extra cash and spend it on a power supply with pre-sleeved cables or something a bit fancier.

That said, ultimately we're still very happy with how this build turned out, and with that Kraken slowly pulsating away at its heart. It's certainly a good-looking rig.

BENCHMARKS

	ZERO-POINT	
Cinebench R15 Multi (Index)	1,320	1,630 (23%)
CrystalDisk QD32 Sequential Read (MB/s)	3,438	4,918 (43%)
CrystalDisk QD32 Sequential Write (MB/s)	2,955	2,746 (-16%)
Middle Earth: Shadow of War (fps)	75	83 (11%)
Total War: Warhammer II (fps)	65	71 (9%)
Assassin's Creed Odyssey (fps)	45	51 (13%)
3DMark: Fire Strike (Index)	19,597	21,586 (10%)

0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

Our zero-point consists of an AMD Ryzen 5 2600X, 16GB of Corsair Dominator Platinum RGB @ 3200 MT/s, an Asus GeForce RTX 2080 OC Edition, and a 1TB WD Black M.2 PCIe SSD. All tests were performed at 1440p at the highest graphical profile.

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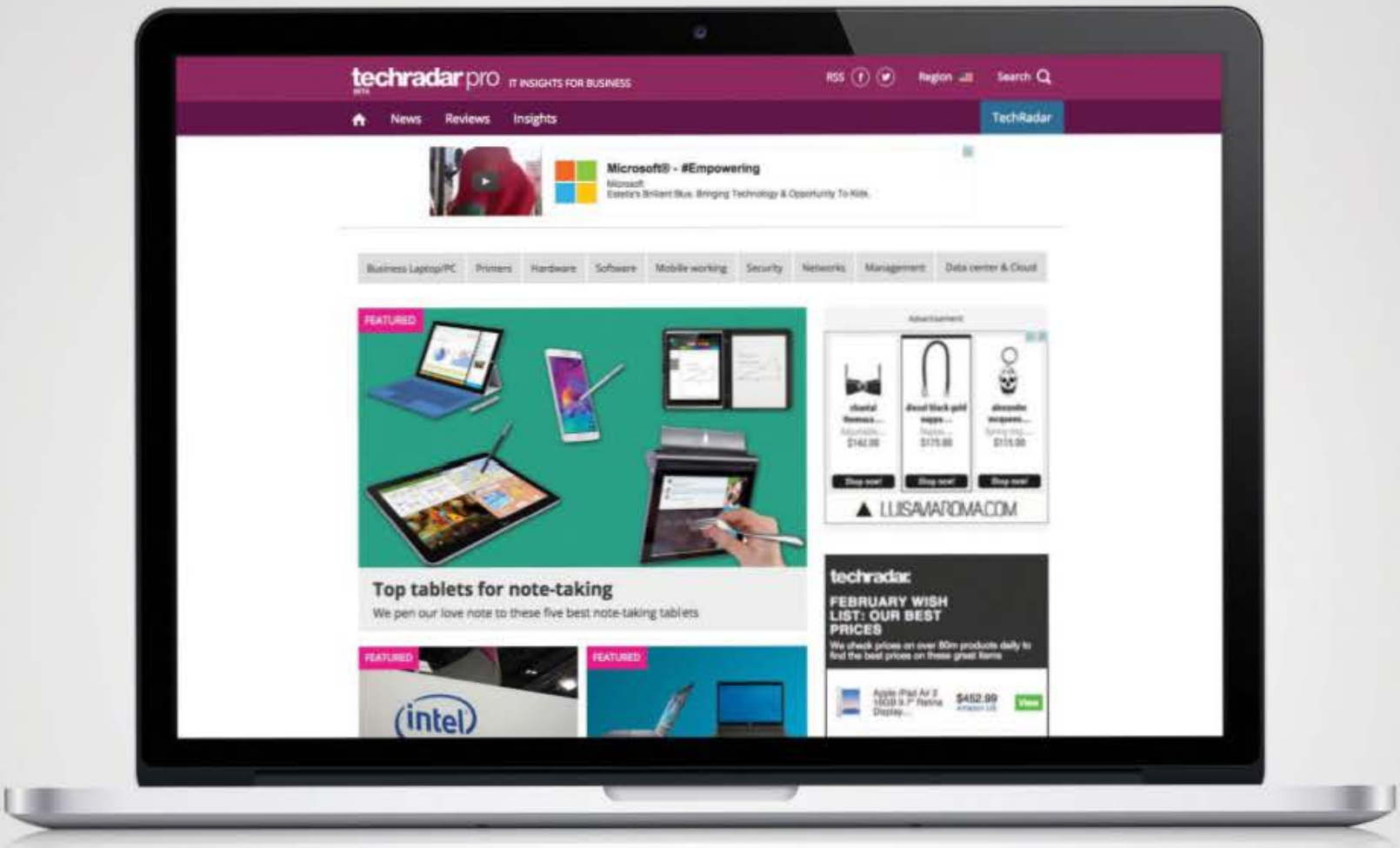

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REVIEWS

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Asus TUF Gaming A15 FA506

Pretty far from FUBAR

AMD'S 4000 SERIES of Ryzen CPUs has finally arrived for laptop manufacturers to stuff into their systems, and the first we'll be taking a look at is the TUF Gaming A15 FA506 from Asus. This powerhouse gaming laptop comes with the 8-core, 16-thread Ryzen 7 4800H, although a 6-core 4600H model is also available.

So, how does this processor measure up? Performance in CPU-bound tests was good, comfortably outstripping last-gen AMD and Intel chips in an exceptional manner that didn't result in heat or noise spikes. The FA506 ran cool throughout our benchmarking process, even using the "performance" preset in Asus's Armory Crate software. A dual fan setup means it isn't silent, but compared to some of the jet-engine gaming laptops we've heard, it's impressively low-key.

This is in part due to Asus's excellent work on the FA506's chassis, but also due to the 4800H's relatively low thermal design power of 45W, which exactly matches the TDP of our zero-point gaming laptop's Intel Core i9-8750H processor. Considering that the newer 4800H hit almost double the 8750H's performance in Cinebench R15, we're impressed.

The FA506 surprises again by being one of the few "military-grade" gaming laptops that actually looks like it could be a piece of military hardware. The brushed metal body is almost entirely black, save for the back of the display, which is gun-metal gray, with a small hexagonal bolt in each corner. As far as we can tell, these are purely aesthetic, but we like it. An RGB-backlit keyboard ruins the image a bit—we can't imagine controlling a Predator missile with rainbow-lit keys—but it's easy enough to turn off.

The FA506 doesn't just look tough; it feels it. According to Asus, the FA506 can survive short drops, vibrations, temperatures up to 49C and humidity up to 95 percent without any lasting impact on. Amusingly, it can also handle freezing temperatures as low as -32C, which you probably won't need unless you live in the frozen forests of the Yukon. We weren't able to test these features with any accuracy, but the FA506 did survive several hours of use on a sweltering Thursday in April.

STRAIGHT SHOOTER

We know what to expect by now when it comes to gaming framerates; we're looking at an RTX 2060 6GB, which provides exceptional 1080p performance with a smidge of ray-tracing on the side, if you don't mind the frame-rate drop. Most titles should be able to hit 60fps at maximum graphical settings, and the 144Hz display means that esports games run ultra-smooth.

Speaking of the display, it's one of the few areas where this laptop fails to impress. It's fine, and the 144Hz refresh rate is a nice addition, but the color density and maximum brightness are definitely lacking. The RGB-lit keys are quiet and have a decent amount of travel, but they feel somewhat squishy; nice for typing, not quite as good for gaming. The numpad and arrow keys are squeezed in beside the main keyboard and proved somewhat frustrating to use with this reviewer's meat paws.

The included 1TB M.2 drive is fast but doesn't hit the peak speeds that PCIe 3.0 SSDs are capable of. However, one boon of the FA506's design is the upgrade potential baked right into the chassis. The hex-patterned bottom panel can be easily removed, beneath which are two replaceable sticks of RAM and a spare M.2 slot. It's a pleasing bonus in a world where all too many manufacturers would prefer that you never even think about cracking open the casing.

So, the 90Whr battery handled over seven hours of continuous use, the surround sound is loud and bassy, and all the ports we expect to see on a gaming laptop are present. The lack of Wi-Fi 6 is a shame, but not a dealbreaker. At $1,200, the A15 FA506 offers solid gaming performance in a sturdy outer shell for a reasonable price, with a super-speedy CPU to boot. It's not going to set the world alight, but it certainly does get our recommendation. **–CHRISTIAN GUYTON**

BENCHMARKS

	ZERO-POINT	
Cinebench R15 Multi (Index)	1,030	**1,875** (82%)
CrystalDisk QD32 Sequential Read (MB/s)	**3,374**	1,741 (-48%)
CrystalDisk QD32 Sequential Write (MB/s)	**2,530**	1,717 (-32%)
3DMark: Fire Strike (Index)	13,610	**15,509** (14%)
Rise of the Tomb Raider (fps)	92	**99** (8%)
Total War: Warhammer II (fps)	62	**64** (3%)
Tom Clancy's Ghost Recon: Wildlands (fps)	49	**50** (2%)

0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

Best scores in bold. Our gaming laptop zero-point is the Acer Predator Triton 500, with an Intel Core i7-8750H, Nvidia GeForce RTX 2060 Max-Q, and 16GB of DDR4-2666. All game tests are performed at 1080p at the highest graphical profile.

VERDICT **8**

Asus TUF Gaming A15 FA506

TOUGH AS NAILS Clean design; good all-round performance; quiet but effective cooling.

SOFT TOUCH Truncated keyboard; display is average; drive could be quicker.

$1,200, www.asus.com

SPECIFICATIONS

CPU	Ryzen 7 4800H
Graphics	Nvidia GeForce RTX 2060 6GB
RAM	16GB DDR4-3200
Screen	15.6-inch IPS-type 1080p @ 144Hz w/ 45% NTSC
Storage	1TB M.2 NVMe SSD
Ports	1x HDMI 2.0b, 2x USB 3.2 Gen 1 Type-A, 1x USB 2.0 Gen 1 Type-A, 1x USB 3.2 Gen 2 Type-C DP 1.4, RJ-45, 3.5mm headphone jack
Connectivity	Wi-Fi 5, Bluetooth 5.0
Weight	5.07 lb
Size	1.0 x 10.1 x 14.1 inches

The FA506 is available in Fortress Gray (shown here) or Bonfire Black.

Viewsonic Elite XG270QG

Viewsonic meets LG in this pristine gaming monitor

OK, SO FIRSTLY let's talk about why you should be excited about this monitor. A quick glance over the spec list suggests there's not actually a lot of new tech here; we've had 165Hz, QHD, IPS gaming monitors with G-Sync for some time now. But there's more to the Elite XG270QG than that. It's a combination of design aesthetics and some new tweaks to the technology that makes it truly impressive.

It all comes down to the panel at its heart. Viewsonic's taking advantage of LG's pioneering IPS Nano Color tech. It's actually a relatively new panel type, first debuting in about 2018, and we've seen very few manufacturers actually take it up in the gaming monitor space. The reason for this is that it adds a fair amount of cost to a screen, but improves color accuracy quite remarkably. With most IPS panels, the biggest issue when it comes to color reproduction in the RGB spectrum is the white backlight that sits behind the pixels. Because this light is entirely white, it emits a considerable amount of additional light wavelengths through the pixel itself (i.e. noise), which in turn can warp certain colors from showing accurately.

To get around this, LG developed Nano IPS. It's a thin layer of light-absorbing material that's coated directly onto the backlight itself. In fact each particle is just below the 2nm mark, which is what gives it its name. These particles absorb those particular wavelengths of light that can otherwise distort a color, which in turn increases both the spectrum of colors you can represent, and how accurately those colors can be displayed. LG states that, with its Nano IPS panels it can achieve a color accuracy of 98% of the DCI-P3 spectrum (or 135% of the sRGB space). That's the spectrum HDR itself relies on. It's actually quite similar to what Samsung has achieved with its Quantum Dot technology, although LG will argue that it has by far the more sophisticated solution.

Now you do see this tech in a lot of the higher-end panels, but these are typically reserved for creatives and those with deep pockets. The monitor itself looks fantastic—the company is clearly straddling that fine line between gaming and professional. There's no ostentatious displays of gaming epeen, nor is it so slick you'd mislabel it as an Apple product. There's plenty of little hints here and there alluding to that gaming heritage. It's got a super-small bezel, a slick, clean "ELITE" logo on its bottom fascia, an ergonomic adjustable stand, and of course RGB backlighting as well.

It's also stupidly well-equipped. It features a 1ms G2G response time, a 165Hz refresh rate, and G-Sync as standard. Combine that with the impeccable color response, and what you're looking at is an exceptionally adept gaming monitor. In fact we'd go so far as to say this is genuinely the first time we've seen a mid-range to high-end gaming monitor that didn't suck for people who enjoyed or worked with color.

That actually makes a lot of sense—in the past we'd easily let go the foibles of a gaming monitor because they provided us with the super-snappy response times or the ridiculous refresh rates, in exchange for color and viewing angles. Vice versa, 60Hz and a 9ms G2G was fine when looking at a bezelless, classy artworker screen. In the case of the XG270QG, it happily straddles both of those, with little concern on either front. On top of that, ghosting is minimal, even under the most intense firefights, G-Sync works well, and 165fps is about as fast as this journalist's eye can tell the difference. Yes, it does come with one heck of a price tag (if you can manage to find it in stock), but for what you're getting, there really aren't any alternatives out there. If you're after the best 27-inch 1440p gaming monitor today that money can buy, the Viewsonic Elite XG270QG is the king. **–ZAK STOREY**

VERDICT

9

KICK ASS!

Viewsonic Elite XG270QG

EXALTED Impeccable color accuracy; massive feature set; clean design; strong ergonomics.

EXASPERATED Pricey.

$695, www.viewsonic.com

SPECIFICATIONS

Resolution	2560x1440
Pixel Density	109 ppi
Panel Type	27-inch Nano IPS
Maximum Refresh	165Hz
Contrast Ratio	1000:1
Response	1ms G2G
Display Inputs	1x DisplayPort 1.4, 1x HDMI 2.0
VESA Mount	100x100
Warranty	3 years

If this is the future of gaming monitors, we're in.

Will we ever see that $255 price mark again?

Asus ROG Crosshair VIII Hero

Potent yet pricey

WHEN IT COMES TO Asus, many tech journalists—ourselves included—have often jokingly stated that its product lines suffer from what's known as the "Asus tax"—they're perhaps a bit more expensive than they ought to be, and much like Nvidia, with its generational jumps in tech, these products regularly see price increases year-on-year that are hard to justify.

Traditionally the ROG Hero line of motherboards has been aimed at the mid to high-end gamer. Whether that's with Intel or AMD, usually you can see these floating around the $200-$250 mark.

The current one we're reviewing? $360 at the time of writing. That's a lot of cash to drop on a motherboard, and it's honestly hard for us to swallow. Even taking a step back in time for a moment, on launch the X470 Crosshair VII Hero was $285, the X370 Crosshair VI Hero, $255. OK sure, X570 is more complex to produce than previous iterations, and there is PCIe 4.0 to consider, which we've been told since the beginning is far more advanced and therefor more expensive to manufacture, but can you really justify a price increase of $105 over the course of three years for what's advertised as a mid-range product? It's a tough one, especially for a motherboard, where mostly you're paying for looks, consistent performance, and connectivity, unlike with a new GPU or processor.

Now, there's no denying that this thing is a well-equipped board. You've got memory support for up to 128GB of DDR4 with a maximum frequency of 4,800MT/s, two PCIe 4.0 M.2 slots both with integrated heatsinks, eight SATA 6Gb/s ports, support for RAID 0, 1, and 10, an impeccable BIOS as always—perfect for an overclocker—and a ridiculous amount of rear I/O on top of all that (there's 12 USB ports, and two Ethernet ports).

It also looks impeccable. Asus really has nailed it with its designs over the years, and despite its perhaps poor first showing when AMD originally debuted its X370 chipset way back in 2017, the company's team-red offerings have certainly matured since that point. The subtle branding, the diagonally cut lines, the use of color, heatsinks, and armor really help to accentuate the overall look of the board quite dramatically—heck, we even like the RGB, although that "HERO" text on the rear I/O is a bit bold to say the least.

As for performance? Well on the whole, and perhaps unsurprisingly, the Crosshair VIII Hero does really well. In Tech ARP's X264 we saw a figure of 43.3fps, Cinebench R15 hit an impressive 2,172 points, and Fry Render managed to complete in 1:58. Power draw was also fairly well-balanced, with it drawing 59W at idle and 152W under load, with some impressively low overclock figures too—no doubt in part thanks to its 14+2 design.

On the whole this is a very good motherboard. Connectivity is impressive, it has a strong amount of rear I/O, the aesthetics are exemplary, and the performance is in line with what we'd expect from an X570 mobo. However, no matter how you look at it, we just keep falling back to that price point again. Regardless of your thoughts on PCIe 4.0, $360 is just a huge number for this product's legacy. The Hero has been known as being middle of the road—not medium range, not high end—and to see it's price climb further up the scale really does make us question what Asus's ambitions are here. If we're honest, this should be the Crosshair VIII Code, a non-waterblocked variant of the company's flagship Formula board, with the former currently absent. Then perhaps apply the Hero name to the ROG Strix Gaming-F, or something along those lines. Is that pedantic? Well yes, it is, but it would certainly eliminate the confusion for the consumer. **–ZAK STOREY**

MOTHERBOARD BENCHMARKS

	Asus ROG Crosshair VIII Hero	MSI MEG X570 Ace
Tech ARP's X264 (fps)	**43.3**	42.3
Cinebench R15 Multi (Index)	**2,172**	2,100
Fry Render (m:s)	1:58	**1:57**
AIDA64 Memory Latency (ns)	**74.9**	75.4
CrystalDisk QD32 Sequential Read (MB/s)	4,997	**5,001**
CrystalDisk QD32 Sequential Write (MB/s)	**4,452**	4,440
Power Draw Idle/Load (Watts)	**59 / 152**	60 / 155
Total War: Warhammer II (fps)	**58**	**58**
Lowest Voltage @ 0000GHz (Volts)	**1.07**	**1.07**
Maximum OC Achieved (GHz)	**4.3 @ 1.08**	4.3 @ 1.09

Best scores are in bold. Our test bed consists of an AMD Ryzen 7 3700X, 32GB of Corsair Dominator Platinum RGB @ 3600, an Nvidia GeForce RTX 1080, and a 2TB Corsair MP600 NVMe Gen4 SSD. *Total War: Warhammer II* was tested at the ultra preset at 1440p.

VERDICT **8**

Asus ROG Crosshair VIII Hero

HERO Good connectivity; strong performance; impressive aesthetics.

ZERO Price hike hurts.

$360 www.asus.com

SPECIFICATIONS

Chipset/Socket	X570 / AM4
Max Memory Support	128GB (4x32GB) @ 4800 MT/s
Storage Support	x8 SATA, x2 M.2 PCIe 4.0
PCIe Support	x2 PCIe 4.0 x16 (x8x8)
Form Factor	ATX @ 12x9.6 inches
Rear I/O	11x USB 3.2 Type A, 1x USB 3.2 Type C, Intel Gigabit Ethernet, 2.5G Ethernet, 5.1 Audio Out, Optical Audio Out, Clear CMOS Button, BIOS Flashback Button

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HyperX Cloud Flight S

A headset with… let us check our notes… wireless charging?

YES, YOU DID READ that correctly: HyperX's new Cloud Flight S gaming headset features wireless Qi charging. Who exactly was asking for this, we're not too sure; maybe drop us an email if you've ever felt the need to precariously balance your headset atop a Qi charging pad.

It's certainly an odd feature to tout, especially given the fact that headsets as a whole don't seem to naturally pair up with wireless charging. A Qi-compatible mouse and mousepad combo makes perfect sense; a mouse is small, with a flat base that's ideal for wireless charging. A headset, on the other hand, is bulky and awkwardly shaped. The Cloud Flight S was designed to counteract these issues, with flat outer earcups and weighting to make balancing the headset easier. It does sort of work; using a basic Qi charging pad, we were able to place the Flight S down and let it begin charging.

There are a few issues with it, though. Only one of the earcups is Qi-enabled, and on regular Qi pads we found that the headset sometimes had to be shifted around before it would start charging. HyperX recommends using its own twin-pad ChargePlay Base, which can accommodate a Qi-charging mouse at the same time. The battery life is impressive, lasting for up to 30 hours between charges. But the real kicker here is that charging via the included micro-USB cable is just quicker and easier.

So it's a gimmick, and a questionable one at that. Luckily, the Cloud Flight S doesn't rely too heavily on it; this is a high-quality, versatile headset in its own right, delivering great sound clarity and maximum comfort. Priced at $160, it's on the steep side for gaming headsets, but don't be discouraged; it's worth the asking price. It connects to your PC via a chunky USB dongle that enables 2.4GHz wireless, the modern standard for wireless headsets, and we didn't notice any sort of audio latency during our tests.

Audio performance is crisp and clear. Dynamic 50mm drivers with neodymium magnets make music rich and bassy, and perfectly punctuate the bombastic staccato of gunfire in games. We used this headset with *Apex Legends*, *Destiny 2*, and Warhammer: *Vermintide II*, and all three sounded fantastic. The sound of a battleaxe colliding with a raider's skull in *Vermintide II* is loud and squelchy; a bit gross, but exactly as it should be.

The physical power and 7.1 surround sound buttons have a satisfying click, and the volume wheel feels firm. The overall build quality is strong, despite the mostly plastic exterior, with a sturdy, extending metal headband inside the casing. The headband padding and ear cushions are made from a soft, breathable leatherette stuffed with memory foam, making this comfortable to wear for hours on end.

On the flat exterior of the left earcup, four slight indentations in the plastic mark the location of the headset's best feature: programmable onboard controls. These four hidden buttons can be remapped using the free NGenuity software, defaulting to functions like mic muting and chat mix. The NGenuity software is lacking in other departments, however. Equalization customization isn't really an option, and while the Cloud Flight S's EQ preset is awesome for games, it won't be ideal for musical professionals.

For us, the main downside is the microphone: A simple, detachable arm mic with an LED mute indicator, it does a reasonable job of blocking out background noise but makes voice communication sound tinny and distant. It's not bad, but for $160 we expected more. If you're using it for anything beyond voice chat in games, you need to invest in a separate standing microphone.

Fundamentally, this is a good headset. It's a bit expensive, and the core selling point is just a gimmick, but HyperX has made up for it with robust construction and sound quality that beats many of its competitors. The Cloud Flight S is worth a look. **–CHRISTIAN GUYTON**

VERDICT 8

HyperX Cloud Flight S

TAKE FLIGHT Good audio quality; robust build and controls; very comfortable.

CRASH LANDING Wireless charging is finicky; unimpressive mic performance; no EQ tweaking.

$160, www.hyperxgaming.com

SPECIFICATIONS

Driver Type	50mm dynamic
Frequency Response	10Hz–20kHz
Sensitivity	-40.5dBV
Design Style	Circumaural, closed back
Microphone Type	Electret condenser
Connection Standard	2.4GHz
Battery Life	30 hours
Weight	0.71lb (0.68lb w/o mic)

Steelseries Apex Pro

The life magnetic, with Maximum PC

STEELSERIES'S APEX keyboards are all respectable offerings—high-quality peripherals for the discerning PC enthusiast. Each model has a dinky display and textured wheel for multimedia controls, and the same degree of overall design polish. But the Apex Pro brings something more than build quality and RGB lighting; it offers an end, finally, to the key-switch debate.

Mechanical or membrane? Linear or tactile? Clicky or quiet? The arguments may rage across reddit forever, but Steelseries has provided the answer with the new OmniPoint mechanical switch. This switch already ticks all the boxes for performance, with an incredibly fast 0.7ms response time an actuation point below 1mm, but here's the kicker: the Apex Pro's OmniPoint keys (which includes the entire main keyboard block, save the function keys, arrow keys and numpad) can be easily adjusted on a per-key basis by the user.

Thanks to magnetic sensors inside each switch, the actuation point of every key can be tuned between 0.4mm and 3.6mm; if you're not familiar with key switches, that's the distance the key must be depressed before it registers a response. 0.4mm is staggeringly low, requiring barely a fingertip resting against the key to register input. It's simple enough to replicate the feel of most common mechanical switch types—such as Cherry MX Red, Brown or Blue—using the custom actuation, so it's easy to recommend this keyboard to just about anyone.

The Apex Pro uses a simple scale for adjusting this. For regular computer use, we found that a lower actuation of two or three worked fine, resulting in a very comfortable typing experience. For gaming, though, setting that scale to seven or above proved useful. The ability to differentiate between keys here is fantastic. We took it for a spin in Riot Games's new twitch shooter *Valorant*, reducing the actuation all the way down to the minimum for the movement keys, and raising it for the ability keys.

It played like a dream; running, crouching, and jumping felt smooth as silk, while it took a firm press of the X key to activate our ultimate ability; no embarrassing misfires here. These magnetic switches are also surprisingly quiet, a far cry from the noisy clattering of some mechanical keyboards. As gaming keyboards go, the Apex Pro is up there with the best of them.

Looking to the outer design, it's a sleek affair all round. There's very little flab here; the whole upper panel of the keyboard is cut from a single sheet of aircraft-grade aluminum alloy, making for a simplistic but very durable frame. Steelseries has trimmed any fat around the edges, giving this full-size keyboard a surprisingly compact feel. Underneath, three curved grooves enable you to easily change the way the power cable is routed. The soft rectangular wrist rest snaps magnetically into place and is large enough to comfortably accommodate your whole palm while you type.

The keycaps might be plastic, but they still feel robust, and feature per-key RGB lighting. The reactive lighting profiles are fun, making the keyboard pulse orange and red when you trip and fall into lava in *Minecraft*, but you can't create your own profiles with per-key customization, which is a shame. More features are reportedly incoming for the Steelseries Engine software, so we'll hopefully see more there in the not-too-distant future.

As we mentioned earlier, every Apex keyboard comes with a tiny OLED smart screen in the upper-right corner. Accompanied by a broad scroll wheel and a lone button, this pixel display shows anything from key-switch actuation sliders to lighting controls for your current Spotify song. It's a nifty, innovative inclusion that we found ourselves using a lot more than we expected to. It is also available on the cheaper Apex models.

The Apex Pro retails at $200—certainly a lot of money for a keyboard, even one as good as this. It simply is worth the price, though; it's been a long time since a keyboard has made us as excited as this, between its cutting-edge aesthetic and awesome performance. The Apex Pro is a great product, hitting all the same high notes as its competitors, and then going a step (or two) beyond with its OmniPoint keys and OLED display. This is a kick-ass keyboard, make no mistake about it.

–CHRISTIAN GUYTON

VERDICT 9 KICK ASS!

Steelseries Apex Pro

TRUE STEEL Adjustable actuation; durable build; slick media controls.

GOLD-PLATED Expensive for a keyboard; no custom RGB profiles (yet).

$200, https://steelseries.com

SPECIFICATIONS

Switch Type	OmniPoint adjustable mechanical switch
Switch Durability	100 million presses
Media Keys	Integrated w/ display
Connection	Dual USB 2.0 w/passthrough
Battery Life	N/A
Wrist-rest	Magnetic
Dimensions	5.48 x 17.19 x 1.59 inches

NZXT H1

Good things do come in small packages

THERE'S A CERTAIN BEAUTY to a super-compact case. The NZXT H1 has a slick, minimalist design, with a perfectly square footprint measuring barely more than seven inches by seven inches. It lays the foundation for a truly incredible mini ITX case. As we examined the H1, we started to wonder if its namesake number alluded to the fact that it could take the number-one spot in the mini tower rankings.

A bold claim, perhaps, but this really might be the best mini ITX case on the market right now, for a multitude of reasons. First and foremost, the level of aesthetic style on show here puts many of NZXT's own cases to shame, with a tinted glass front panel and all-metal chassis, perforated on the other three sides for optimized airflow. Our model came with a bright white paint job, but there's also an all-black version available.

As we know, it's not enough to simply look good. Thankfully, NZXT's dedication to perfection extends to the interior. That small form factor is achieved through brilliant optimization of the internal space. Cables are pre-routed to reduce clutter, and the motherboard is installed with the I/O facing directly down, with an open space at the rear of the base for the cables you have plugged in. The entire outer casing lifts off, leaving an open frame that's surprisingly easy to build in.

The H1 also comes with a handful of extra components to keep its footprint small. First up is an integrated power supply; not an uncommon sight in ITX cases, but not typically as high quality as this one. It is NZXT's own 650W SFX-L modular PSU, a compact block that enables you to remove unneeded cables, and provides more than enough juice for a powerful ITX system.

Next up is the included cooler, a standard AIO cooler with a single 140mm radiator and fan. There's no RGB lighting or tiny pump display here, but the cooler does work well, easily capable of keeping a high-end CPU chilled. We wouldn't recommend doing any intensive overclocking with this case, but the cooler will provide a decent amount of headroom for auto-overclocking.

The last add-on is a flexible PCIe riser, designed to let you mount the GPU vertically. This means the H1 can accommodate most full-size graphics cards, with the GPU fans positioned against one of the perforated metal side panels for superior cooling. It's a neat addition that lets the H1 host high-end gaming and editing rigs, as well as compact work systems.

A drive cage rests at the top of the case, supporting two 2.5-inch SATA SSDs, with toolless access for easy installation. In fact, building in the H1 is a remarkably straightforward process; the PCIe riser is simple to connect, and the glass panel pops out with only a little exertion. Above that drive cage is the front I/O, cables already neatly routed down to the motherboard plate. The I/O is minimalist, with a single USB-A, a USB-C, an audio jack, and a power button, the latter of which has a light-up ring surrounding it. USB-C support is great, but this won't be ideal if you like plugging lots of things into your PC.

But here's the kicker, the H1 costs a hefty $350. It's an eye-watering price for a case, especially a dinky ITX model. There's no support for micro-ATX cases here, as in some mini towers, and no room to install additional case fans. The drive cage also doesn't support standard 3.5-inch HDDs, which is a bum note if you like big (but still affordable) drives.

It's worth bearing in mind that it does include a PSU and cooler; the power supply alone is worth upwards of $100, as NZXT's ATX 650W sells for $120. The H1 also comes with a three-year overall warranty, and a ten-year warranty for the power supply. It's pricey, but it's hard to find a case that matches the H1's stylish and intelligent design. **–CHRISTIAN GUYTON**

VERDICT 9 KICK ASS!

NZXT H1

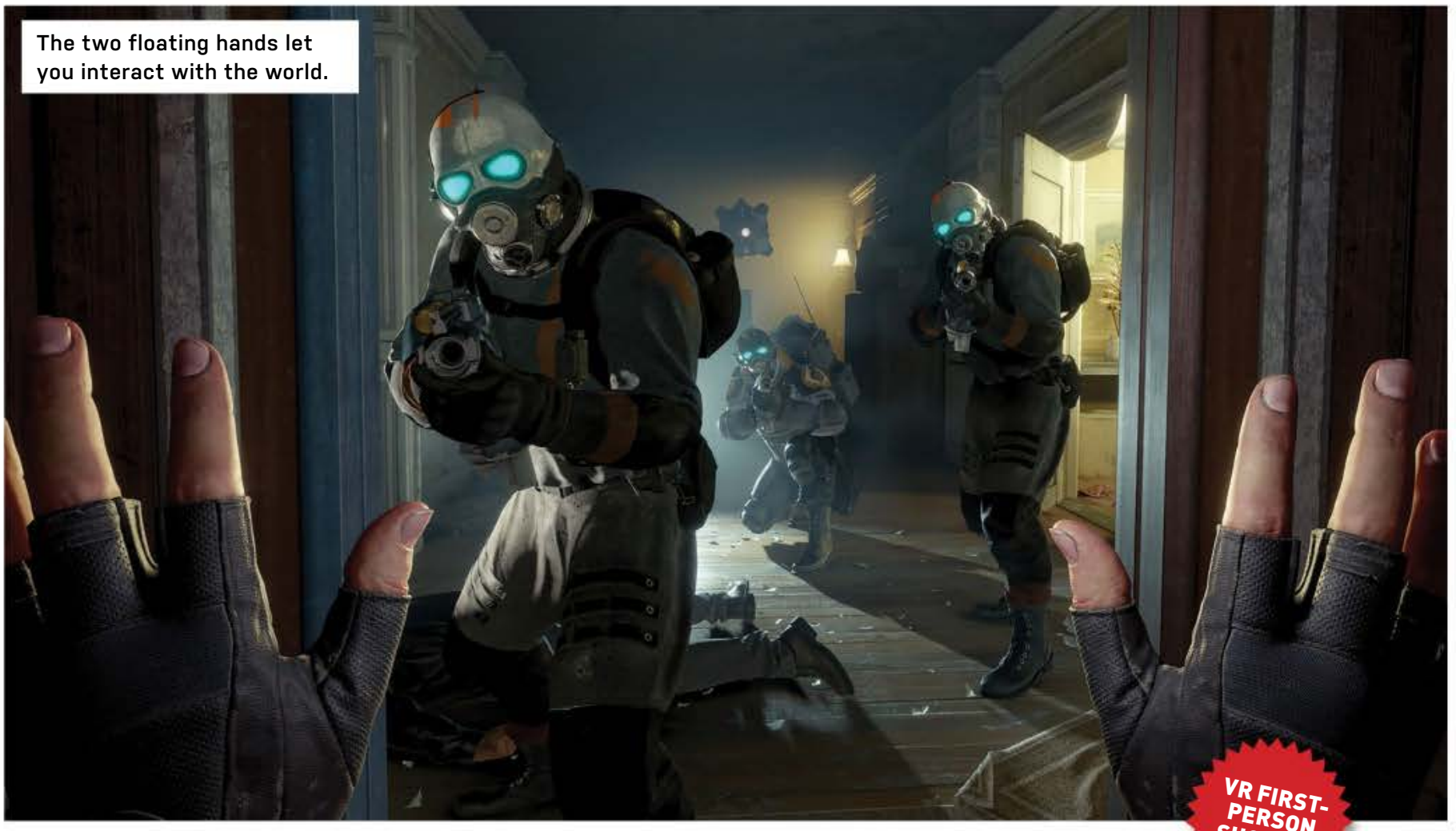
NUMBER ONE Very compact layout; exceptional cooling; included PSU and AIO cooler.

PATIENT ZERO Seriously expensive; no HDD support.

$350, www.nzxt.com

SPECIFICATIONS

Form Factor	Mini tower
Motherboard Support	ITX
Colors Available	White, black
Window Available	Yes
3.5-inch Support	N/A
2.5-inch Support	2
Radiator Support	140mm (integrated)
Fan Support	N/A (integrated)
Dimensions	7.4 x 15.3 x 7.4 inches
Graphics Card Clearance	12 inches



The two floating hands let you interact with the world.

VR FIRST-PERSON SHOOTER

Half-Life: Alyx

Just a girl, sitting in front of a zombie

GO TO THE DUSTY CUPBOARD, the abandoned attic, the damp basement, wherever you last saw your VR helmet. Brush aside the cobwebs, blow off the ants, locate all the cables, and put the thing on for what feels like the first time in years. This is worth it. Alternatively, pay a thousand bucks for the Valve Index.

In the gap between existing games, five years before the events of *Half-Life 2* if you can remember back that far, Alyx Vance is a scrappy member of the resistance movement fighting a guerilla war against the Combine after their suspiciously easy victory over Earth's armed forces. Her father, Eli, has been taken by the occupying aliens, and so Alyx heads off to rescue him. It's not a complicated plot, but the way you go about following it is what makes the game exceptional.

All you see of her are a pair of floating hands, fitted with gloves that have a similar effect to Gordon Freeman's gravity gun, minus the hurling saw blades into zombies. The entire game hinges on those hands. You can pull just about any object towards you thanks to the gloves, and reloading your weapons is an entirely manual, three-stage process that sees you pull out the old mag before reaching over your shoulder for a new one, before clicking it home. This process is complicated by being in the dark, which happens often, and by having headcrabs jumping at you.

While there is a new enemy to fight, it's the subtle makeover of the familiar ones that's most shocking. The poor, weak headcrabs, never much more than crowbar-fodder, are now plump and horrifying. The zombies they create turn from pathetic to lethal. Ant-lions roar and thunder. Even the converted human police seem bigger and chunkier, especially as seen from Alyx's slight viewpoint.

Movement, often a problem in VR games thanks to motion sickness, is handled well, with several different schemes available according to the preferences of your inner ear. Short teleporting hops are a good compromise—it can take away some immersion if you think about it, but *Half-Life* was never a circle-strafing blaster in the vein of *Doom*, and you're never able to use it to your advantage like *Dishonored*'s Blink ability.

Just as 3D movies filmed with special cameras look better than 2D productions converted into 3D during post-production, so *Alyx* benefits from being designed for VR from the start. From writing on glass with Sharpies to the staggering scale of a strider—made terrifying again by your inability to escape its awful noise and biomechanical, chicken-carcass-meets-seafood legs—there are moments here that feel like massive strides forward, rather than mere retreads of past glories.

If you've even the faintest flickering of interest in VR, this is the new getting-on point. The bar, hefted aloft by Gordon Freeman since 1998, has been raised once again, this time to heights unimaginable at the time of the resonance cascade. As it should be after a 13-year wait, *Alyx* is a genuine moment of cultural significance, and the more devs who pile in on this bandwagon, the better. And if you don't have a headset, a non-VR mod is already available as we type this. **–IAN EVENDEN**

VERDICT 9 KICK ASS!

Half-Life: Alyx

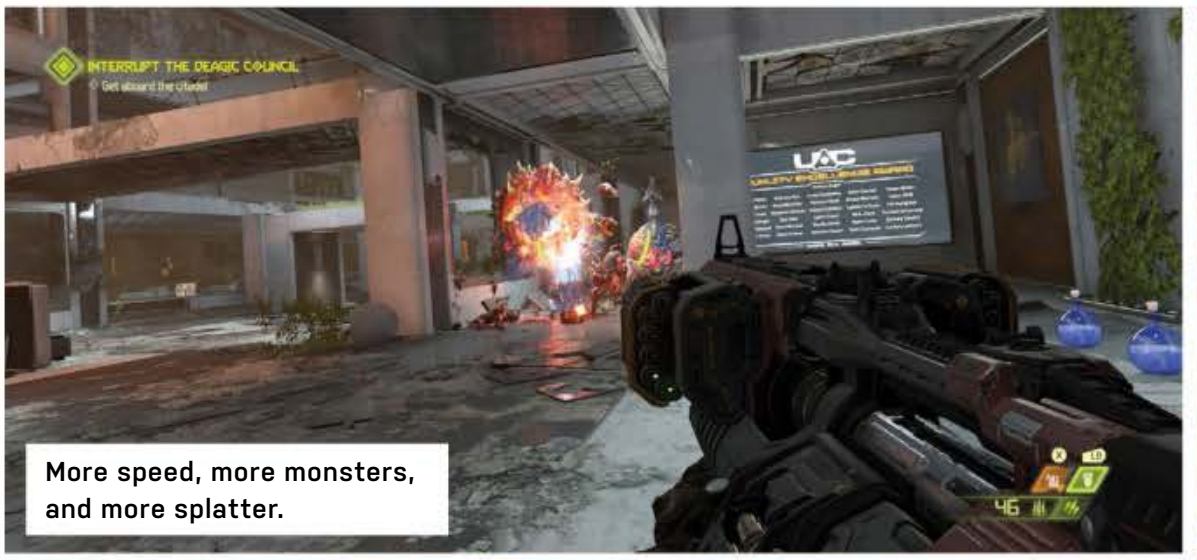
ALYX-CELLENT A stunning and terrifying VR ride.

ALRYTE Perhaps too much time spent in tunnels and other dark places, jump scares.

RECOMMENDED SPECS CPU, Core i5-7500 / Ryzen 5 1600. RAM, 12 GB. GPU, GTX 1060 / RX 580.

$60, half-life.com, not yet rated

© VALVE



More speed, more monsters, and more splatter.

Thought is needed to tackle enemies now.

The idTech 7 game engine adds a riot of color to the world.

Eternal includes a rich lore behind the story.

FIRST-PERSON SHOOTER

Doom Eternal

Rip and tear, but obey the lore

OF ALL THE LONG-RUNNING franchises, the least likely to reinvent itself was surely *Doom*. It's done that already, with *Doom 3*'s descent into survival horror, rectified with a 2016 game that returned to the shooty mayhem of the first two titles.

Eternal is, on the surface, more of the same. There are demons, many of them horrifying biomechanical creatures, and they're invading Earth. Actually, they seem to have succeeded. A wonderful early scene depicts an enormous horned creature, like Hellboy with a raging hangover, walking through a ruined city flowing with lava, and showing, for a glorious moment, a giant mech suit. There's a boss battle there, you think. Us in the mech vs that red abomination. The fact it never happens is a disappointment, but perhaps the only one.

Every iteration of *Doom* (except *Doom 3*) seems to increase the speed, the monster count, and the splatter. *Eternal* doesn't let us down here, taking everything that was added to the 2016 game and piling more on top. That the starting weapon is the shotgun rather than a pistol should tell you a lot—*Doom*'s signature weapon relegated to a mere zombie-popper.

It's not just the new weapons and enemies either. *Doom* has been imbued with a plot and lore. And wow, it's complicated. There's flashbacks, ancient aliens, creatures called hell priests that need to be chased across the world and beyond. The Icon of Sin grows a body, but John Romero's severed head is nowhere to be seen. Weapon upgrades are more complicated, and thought needs to be put into which one to use against which enemy, rather than blasting away with whatever you've got the most ammo for.

The need to keep your guns and health topped up drives you to kill enemies in particular ways, although there are also health pickups scattered around. Staggering an enemy makes them flash blue, and charging in with a melee attack rewards you with a special "glory kill" animation and drops health. Killing an enemy with the chainsaw drops ammo, somehow, making the prioritization of targets essential if you're to have enough bullets left to deal with the big guys, once you've tooled up using the cannon fodder.

Special mention must go to idTech 7, the engine very much purring beneath the hood. Not only has it added a dismemberment system that sees you blow chunks of armor and flesh off your enemies to reveal the bones beneath, but the step up to new technology has added color to *Doom*'s world. No longer are we in a world of grays and reds, but we see blue and yellow illuminated signs, a constant orange glow from lava, and even a few potted plants to brighten the place up. There also seems to be more in the way of intelligence at work, with enemy infighting more pronounced, and flanking that presses you to keep moving. System requirements are very low, with 4K Ultra reachable on modest hardware. Push the slider up, and you'll be amazed how far it goes before ruining the frame rate.

Eternal may be more of the same—what did we expect with a name like that?—but its additions to the game mean that there's more to it than dumb blasting if you want it. And if you just want dumb blasting, that's fine too. **–IAN EVENDEN**

VERDICT **8**

Doom Eternal

EMBELLISHED Fast, smooth, and full of things to shoot at.

HELLISH New additions may feel like too much for purists.

RECOMMENDED SPECS CPU, Core i7-6700K / Ryzen 7 1800X. RAM, 8GB. GPU, GeForce GTX 970, AMD RX 480.

$60, https://slayersclub.bethesda.net, M-rated

© BETHESDA

LAB NOTES

ZAK STOREY, EDITOR

So, now I'm a Brother Finally!

Communicating in a COVID world

I HAVE GOOD NEWS! I'm a brother. My mom and stepdad are now the proud parents of three tiny tykes, and one big one—me.

I've been an only child for the last 28 years. My mom and dad were very young when they had me, and although they were together for some time, eventually they separated when I was 16. Fast-forward three years, and with my blessing my mom, moved to New Zealand to live with her then-boyfriend, and now husband. It made sense—I was about to head off on my own adventures, so why should she stay when she could be happier out there?

Now this story does get a bit complex here, as my stepfather suffers from a condition called locked-in syndrome, brought about by a sporting accident in his youth, and in fact you can watch a really good documentary about him and my mom that explains it all here: bit.ly/2WYsWxA. Their relationship—and mine with them—has always flowed around technology. Social media brought them together, emails connected them, and that same tech keeps her in touch with me and my family today. But for my new siblings there's a problem, which got me thinking.

With the world in the state that it is, the sad fact is I likely won't be able to see them all properly for some time. And although I've joked that I wouldn't visit until after they've stopped crying at night, my genuine desires are obviously different. I haven't seen my mom in over five years, and that was before all this COVID-19 madness, so losing the opportunity to do that, and visit my new siblings now, seriously sucks.

If this extends further, how is my relationship with these whippersnappers going to develop? Do I have to wait for them to be able to speak, write, and type? I know tech is the solution, but it's finding that answer in this new isolated age that I fear may be the bigger challenge.

Yep three kids is going to be a lot of work!

INDUSTRY INSIDER

What happened to the days when you could buy a triple-A videogame and be reasonably confident that it would provide a complete experience, or download a DLC expansion, knowing it would add hours of fresh, new content?

Now it feels like every big developer is intent on providing their games as a continuous "service"; not something to be enjoyed and ultimately completed, but a never-ending drip-feed of just enough new content to keep players invested, with incentives to log in and play every day, or experience that FOMO. The "season pass" is the worst offender of late. A few years back, you might've bought a season pass for *Call of Duty: Black Ops* and received four decently sized DLCs across the year. The passes were cheaper than buying the DLCs separately, so it wasn't a bad deal.

But now, a paid season pass seems to only last a few months, and rather than proper content drops, they "unlock" a shallow progression system that rewards you with hollow cosmetic rewards for playing the content you already have. *Fortnite*, *Apex Legends*, *Destiny 2*, and many more are guilty of this, and for gamers it's turning frustration into outrage. How long can publishers keep this up, before players demand more?

© GETTY IMAGES

Alphacool Eisbecher 150mm Acetal Reservoir

OH NO, we're talking about a reservoir. What has Geek Tested become? Hang on a second, before you turn the page, this is quite an interesting tidbit into reconfiguring one of our more complex builds.

A few issues back (Holiday 2019) we took a look at building an SLI, liquid-cooled 4K gaming PC, complete with twin EVGA GeForce RTX 2080 Supers, and a bevy of high-end hardware. Now, when we embark on building a liquid-cooled system like that, we typically lean more in favor of aesthetic quality rather than pure performance. That's important to note for a number of reasons.

We pride ourselves on our top-notch photography here. Often that means we forsake drain ports and serial loops in favor of more elaborate setups, to better showcase the rig. In this case we used a parallel loop—not only because it looked good, but because it was something we'd never really done before.

So in a serial loop you go from one component to another, with a single length of tubing in between. It's the most efficient way of liquid-cooling. In a parallel loop, you typically have two or more components in a chain connecting to each other, then back down. In our case, we went from the GPU up to the next GPU, into the CPU, and back down through the two graphics cards and into the reservoir, which in turn reduces flow rates for the top-most components.

When we primed the loop, it presented a few problems, mostly because it's difficult to get the coolant to the CPU block to begin with, and during testing we realized we needed to run the pump at 100 percent permanently to get the coolant to flow around the GPUs and the CPU. If you don't, CPU temps skyrocket dramatically.

This is now my workstation PC. Over time, the right-most tube of the CPU portion builds up a massive air bubble and needs to be tilted on its side every four to five days to move it back to the reservoir. So before lockdown, I grabbed some liquid-cooling gear, and I ordered some coolant and a blitz kit to clean the loop.

After draining it, I removed one of the tubes from the parallel GPUs, then ran the right-most CPU tube to the top of the reservoir, taking advantage of a T-junction fitting, with an additional port to fill the loop again. Below the reservoir I reconfigured that 90-degree bend to the pump into another T junction, this time with a ball valve drain port on one side, and a myriad of 90-degree fittings and a straight length of tubing on the other.

I blitzed the loop afterwards (which requires some chemicals, running it for 24 hours, draining it, then flushing it three times with deionized water). However, the res setup looks awful. And there's no easy way of reconfiguring it, as the EK 150mm res I have only has a single port in the roof, and one viable port in the bottom.

Alphacool's latest reservoirs change that up. They have four G1/4-inch ports in the roof and five ports on the bottom. That gives me far more options on how to configure the loop. After installing it, it should look cleaner and be easier to maintain. Right now I could pop it full with coolant, and it'd run better than ever, but this is *Maximum PC*! Sometimes you've gotta invest to put those PC woes to bed. **–ZS**
$45, www.alphacool.com

© WWW.DONKEY.TEAM

EDITOR'S PICK

Chritian Guyton, Staff Writer

LAST OASIS

Last Oasis styles itself as the first "nomadic survival MMO", and it took me a while to grasp what that meant. As MMOs go, it initially appears to follow the trends; you spawn into the desert, near-naked and unarmed, tasked with slaying a handful of AI-controlled mobs to gain experience points and crafting materials. The combat is real time, with a three-stance melee system, so there's no sitting around tapping ability hotkeys, hoping the numbers popping out of the enemy are bigger than the numbers popping out of you. Tools spice things up, like a grappling hook.

The point where *Last Oasis* started to set itself apart from the crowd came once I crafted my first Walker; a steampunk contraption of wood and iron, striding across the desert on six spindly legs. Walkers are key to the experience; the in-game lore states that after an apocalyptic event stopped the planet from spinning on its axis, only a narrow, shifting strip of land remains habitable as the Earth orbits the Sun. There's a nice bit of ludonarrative connection here, as the game world moves forward slowly but constantly, meaning that you can never stay in one place for too long.

Larger, multiplayer Walkers with huge sails and weapon emplacements are also vital for the most fun thing in *Last Oasis*: monster hunting. Giant beasts lurk beneath the dunes, from hulking crustaceans to a sandworm that would make Frank Herbert proud. An early scuffle with the latter saw our Walker badly damaged and two of my allies dead; we beat a hasty retreat to a nearby jungle, only to be promptly picked off by vulturing players with deadly ranged weapons. This is a hostile, cutthroat world. I'm in love.
$30, www.donkey.team

LETTERS

WE TACKLE TOUGH READER QUESTIONS ON...

> Wiry Beards
> M.2 Heatsinks
> $500 Pro Build

Letter to the Editor

I was sorry to see you go and doubly glad to see you back. Now about that wiry bird's nest at the bottom of your face; it makes you look like a man-mountain, the kind you'd expect to see with an axe over his shoulder and holding a jug of XXX in his other hand. Yes, it cuts out a p-i-t-a morning job but it looks so unprofessional, scruffy, unkempt... Maybe you wanted to look older or something, but that's totally unnecessary when you've got your talents. Welcome back.

–Gareth Wills

EDITOR ZAK STOREY RESPONDS: First I just wanted to say thank you for the kind words, I do appreciate it. It's quite nerve-wracking taking over as editor of *Maximum PC*, never mind when you're in the midst of a global crisis, so I'm glad to see folk are happy to see me at the helm.

As for the beard! Reason I'm growing it at the moment is because it's sort of a coping mechanism for my dad's side of the family. When my grandma was diagnosed with leukemia in 2016, it was the first time my grandpa ever grew a beard, and so I grew one too, and so did my old pops in solidarity, mostly because it annoys my grandma and we're awful people. We shaved them off when she went into remission.

Last year in August she was re-diagnosed and given 18 months to live, which sucks, there's no way around that, and then without discussing it, all three generations of Storey started growing their beards again and haven't stopped since. We don't really talk much emotionally, so I think this is our way of connecting with one another, and knowing we're here for each other through the generations. Also I'm really short—5'8 and a half! So man-mountain is a bit of a stretch.

That said, I don't intend to keep it. Well maybe. I've been in discussions with Alphacool's PR—the modder who helped me out in July 2018's liquid-cooled build—and we've been toying with the idea of doing a head-to-head build off, between me and him. Plan is to build a liquid-cooled ITX system each, using a small, bespoke custom ITX case from a company called Hydra (based in Italy), on a strict budget. He'll be using Alphacool, and I'll likely be going with EKWB. Then either we'll raffle them off, or do a random giveaway, all the while running an online poll to see whose build is best. The loser of that poll has to have their beard shaved off, live on stream. All this will be featured in the mag too, and hopefully we can raise money for a good charity in the process. Obviously there's a lot of details to work out there, but we're aiming to do this in September or October time, lockdown permitting.

Why the RTX 2080 Super Over the Ti?

I have two questions. I noticed on your turbo builds you recommend the RTX 2080 Super over the 2080 Ti, is it just due to cost? Or is it cost-to-performance ratio?

Second question: Is there a noticeable difference between the 3900X and the 3950X chips? I bought an MSI X570 board for the chip, I mainly play *SWG*, and *World of Tanks*. Sorry to hear you guys had to cut back.

–Parrot

STAFF WRITER CHRISTIAN GUYTON RESPONDS: The main reason is the cost-to-performance ratio. While the 2080 Ti does wipe the floor with just about everything else in terms of raw performance, the fact that it's also ludicrously expensive for a GPU means we just can't recommend it in builds where we try to keep the price down. The RTX 2080 Super and 2070 Super are the best high-end GPUs on the market right now if we're talking about performance per dollar spent.

For the second question, essentially the Ryzen 9 3950X has four more cores (and therefore eight more threads) than the 3900X, but those cores are actually clocked a tad lower at base, so it's only a bit faster for most tasks. The 3950X also doesn't come with a stock Wraith cooler from AMD, if my memory serves correctly! Both chips have the same 7nm architecture with PCIe 4.0 support. They have the same TDP, both are unclocked (the 3950X has slightly better overclocking headroom), and neither has integrated graphics. The 3900X is significantly better value for what you're doing.

A Different Build

I have been a subscriber of your magazine for over 20 years now. Although I am

↘ submit your questions to: comments@maximumpc.com

not a gamer at all, I enjoy the magazine very much, because it is very informative and educational.

I have never built a system since I always found prebuilt ones much cheaper, and they worked fine for my needs, but I am at a point where I would like to build one. Since I am not a gamer none of the systems in your magazine work for me, can you please either: 1—Have a yearly feature in the magazine for the rest of us non-gamers, with three systems; budget, mid-range and turbo, including monitors. Systems that will be perfect for everyday computing and using software such as Libre Office, GIMP, Polarr, Krita, Inkscape, Cakewalk, Blender, Scribus, Shotcut, Audacity, etc. Or, 2–email me with recommendations for such systems. Thank you very much. **–Tali Kadosh**

EDITOR ZAK STOREY RESPONDS: I'm glad you brought this up, we're actually running a feature next issue with a build that might just tick all those boxes. We're talking 16GB of DDR4 memory, a 1TB M.2 PCIe SSD, and a stylish case for just under $500, not including operating system.

Now I kind of don't want to say this—it's AMD, don't scold me. We know we've been doing a lot of AMD systems lately, or at least have been before my tenure. However, we're a bit locked down right now, our main offices where we store the majority of our hardware are all locked up, but at time of writing we're hoping to get back in the office within about four weeks or so, meaning that after the next issue things should hopefully be getting back to normal and we can balance the coverage far better.

One thing I would say is that a lot of those programs do benefit from having a dedicated graphics card. You don't necessarily need a super high-end one, but a lot of photo-editing and video-editing applications perform far better with a dedicated GPU, something like an Nvidia GeForce GTX 1650 or an AMD Radeon RX 570. We'll do a feature on this later in the year that proves our point a bit. And I totally agree, I'm going to make it a mag ambition to hit a lot more price points, and build a larger variety of systems than just $1K+ gaming builds. When things are back to normal, I'd like to push perhaps even two builds a month quite regularly.

[NOW ONLINE]

HOW TO OVERCLOCK YOUR INTEL CPU

Overclocking Intel processors used to be complicated. Nowadays, motherboard manufacturers have created automatic overclocking software and one-button predefined presets in the BIOS. While they both produce satisfactory Intel overclocks, they're not perfect. More often than not, you could achieve better results by taking the time to manually overclock your Intel CPU instead of having software do it for you. You'll also learn more about your system.

When you run an Intel processor outside of the manufacturer's specifications, you void the warranty. There's also a possibility of premature failure if you overclock an Intel CPU incorrectly. But if you approach overclocking responsibly, you can squeeze every last MHz out of the processor.

Read the full article: https://bit.ly/34UBpnw

M.2 Heatsinks

Hello, It was nice to see my choice of SSD featured in the turbo build in your February 2020 issue (Yes, I'm a bit behind). I went with the Sabrent Rocket NVMe 4.0 1TB. It has been a fantastic choice so far. This brings up a question on heatsinks (HS). These NVMe 4.0 drives get really hot. I did not get the HS with my SSD. I used the very good HS built into my MSI Pro Carbon MB. I have read a lot of conflicting info on the necessity of using HS on SSDs. Some even say they can reduce the life of the memory chips as they require heat to function correctly, and only the controller needs cooling. What's the answer; HS yes or no?

Also, a motherboard HS only cools one side. What about SSDs with chips on both sides, like my 1TB? How will that affect the SSD? Can you please clear things up on SSD heatsinks? **– GerryKn**

EDITOR ZAK STOREY RESPONDS: This is a good question, and you're right, NAND flash in particular prefers higher temperatures as it increases its longevity. This is to do with getting the electrons to move from the transistor gates for each memory cell (we should really do an article on this), so they don't decay.

On the flip side, the controller itself—in your case the Phison PS5016-E16—is effectively a small processor. It connects the NAND chips to the storage interface, and transfers data between the NAND and whatever hardware needs it via the interconnect. Now like most processors, when controllers get hot they throttle themselves. It's why during long data transfers on M.2 SSDs speeds fall off a cliff.

What manufacturers typically do is place the controller on top of the M.2 stick, so that cool air can pass over it and passively cool it, or it can make contact with a heatsink. A lot of the time the controller is nickel-plated as well, again to help disseminate that excess heat.

Most heatsinks only make direct contact with the controller rather than the NAND flash chips. So their purpose is to cool the controller, rather than the NAND chips themselves. You'll notice the controller is almost always taller than the NAND because of it.

That's why the M.2 connection interface has that notch too—it forces you to install your PCIe drives one way, so the controller is always on top facing away from the motherboard. You'll also notice M.2 SATA SSDs can be installed in either orientation. Again this is purely down to heat and the fact the controller just won't get as hot, as it's only transferring at a maximum of 550GB/s. In theory motherboard heatsinks aren't as good as ones included by an SSD manufacturer, but they're better than nothing, as far as performance is concerned.

We're also at a point where the endurance on NAND flash is quite impressive anyway, so the difference in temperature shouldn't have a huge impact on longevity.

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CPU	AMD Ryzen 5 3600 NEW	$175
GPU	MSI GeForce GTX 1660 Super 6GB NEW	$240
RAM	16GB (2x 8GB) Team T-Force Vulcan Z @ 3,000MT/s	$68
SSD	120GB Adata SU650 t 2.5" SATA III NEW	$24
HDD	1TB Western Digital RE3 WD1002FBYS	$28
OS	Ubuntu Desktop Linux 18.04.3 LTS 64-bit	$15

Approximate Price: $727

IN ORDER TO SAVE A BIT OF CASH on this build, we cut back from the ASRock B450 motherboard we had been using to a B450M offering from MSI. For the unaware, the main difference between B450M and B450 is the inclusion of DisplayPort connectivity on B450 boards, as opposed to DVI-D on B450M boards. Since we're using a discrete GPU, though, it won't be a problem. A price hike on the Ryzen 5 2600 and a sale on the newer Ryzen 5 3600 encouraged us to upgrade the CPU, bringing up this system's overall performance with faster cores and the same Wraith Stealth stock cooler. GTX 1660 Super cards are no longer on sale, so we've switched to the still-affordable MSI model. Lastly, we've returned to the super-cheap Adata SU650 SATA drive, since the Patriot drive we had been using is no longer on sale at the time of writing.

MID-RANGE

INGREDIENTS

PART		PRICE
Case	Fractal Design Meshify C	$85
PSU	550W Cooler Master MWE Silencio Fan 80+ Bronze NEW	$63
Mobo	Gigabyte Z390 Gaming X NEW	$140
CPU	Intel Core i5-9600K	$200
Cooler	Corsair A500 Dual Fan	$100
GPU	MSI Radeon RX 5700 8GB	$330
RAM	16GB (2x 8GB) Team T-Force Vulcan Z @ 3,000MT/s	$68
SSD	500GB Western Digital WD Black SN750 M.2 PCIe NEW	$80
HDD	1TB Western Digital RE3 WD1002FBYS	$28
OS	Windows 10 Home 64-bit OEM	$100

Approximate Price: $1,194

GOOD NEWS FOR TEAM BLUE FANS; the Core i5-9600K has dropped by 30 bucks, bringing it to the very reasonable price of $200. In fact, that's the best value we've seen any mid-range Intel chip go for in recent months, so snap it up. We upgraded the motherboard this month, swapping from the previous ASRock board to the slightly more full-featured Gigabyte Z390 Gaming X, for just $5 more. The MSI model of the Radeon RX 5700 8GB remains the cheapest option by far, so we stuck with that. We did, however, swap out the M.2 SSD to Western Digital's 500GB SN750 from its WD Black range, a high-speed gaming drive that kept our price on balance. Lastly, the Corsair PSU we had been using leapt up in price, so we switched it for a more affordable 550W offering from Cooler Master, keeping that 80+ Bronze seal of approval.

UPGRADE OF THE MONTH

AMD RYZEN 5 3600

We made a lot of changes this month, but only one could be the upgrade of the month: the blessed Ryzen 5 3600, mid-range champion of the third-gen Ryzen chips. Six cores and 12 threads for under $200 is a great deal, using AMD's cutting-edge 7nm architecture and PCIe 4.0 support. It's a fantastic all-rounder CPU, with relatively low power consumption and an included cooler. You might have noticed that we didn't put a PCIe 4.0 SSD in the budget build; that's because those drives are anything but budget right now, since none under 500GB are currently available.
$175, www.amd.com

DISASTER STRIKES, and we're forced to throw a load of cash at the Turbo build. EVGA's sale on the SuperNOVA PSUs has come to a close, so we're shifting over to NZXT's E850, keeping our system wattage the same but adding nifty features like silent running under 100W and onboard DSP. The NZXT PSU might be expensive, but it also comes with a 10-year warranty, so it's worth the price.

Something strange is happening with TR4 motherboards, too. Between COVID-19 affecting supply and production, online retailers like Amazon diverting resources to essential deliveries, and (possibly?) an uptick in PC-building at home, Threadripper board prices have risen, and the humble ASRock X399 Phantom Gaming 6 mobo we had been using is out of stock. We've made the change to ASRock's X399 Taichi, but that move cost us nearly $100. However, the pandemic apparently hasn't affected Threadripper stocks, as the 2950X is down by another 30 bucks from last month.

The EVGA CLC 360 is no longer on sale either—we're taking a beating here this month. We've gone down to two fans with the awesome value Enermax Liqtech II 280, although these are larger 140mm units than the three 120mm fans attached to the CLC 360. We swapped our 2080 Super over to a Gigabyte model to keep price rises in check, but we did still see an overall price hike on this build. Here's hoping next month brings some good sales.

For more of our component recommendations, visit www.pcgamer.com/hardware/buying-guides/

INGREDIENTS

PART			PRICE
Case	NZXT H700i		$168
PSU	850W NZXT E850 80+ GOLD	NEW	$200
Mobo	ASRock X399 Taichi sTR4	NEW	$320
CPU	AMD Threadripper 2950X		$650
Cooler	Enermax Liqtech II 280	NEW	$110
GPU	Gigabyte GeForce RTX 2080 Super Windforce OC 8GB	NEW	$720
RAM	32GB (2 x 16GB) G.Skill TridentZ RGB @ 3600MT/s		$187
SSD	1TB Seagate BarraCuda 510 M.2 PCIe		$160
HDD	2x 3TB Seagate BarraCuda Compute		$160
OS	Windows 10 Home 64-bit OEM		$100
Approximate Price:			**$2,775**

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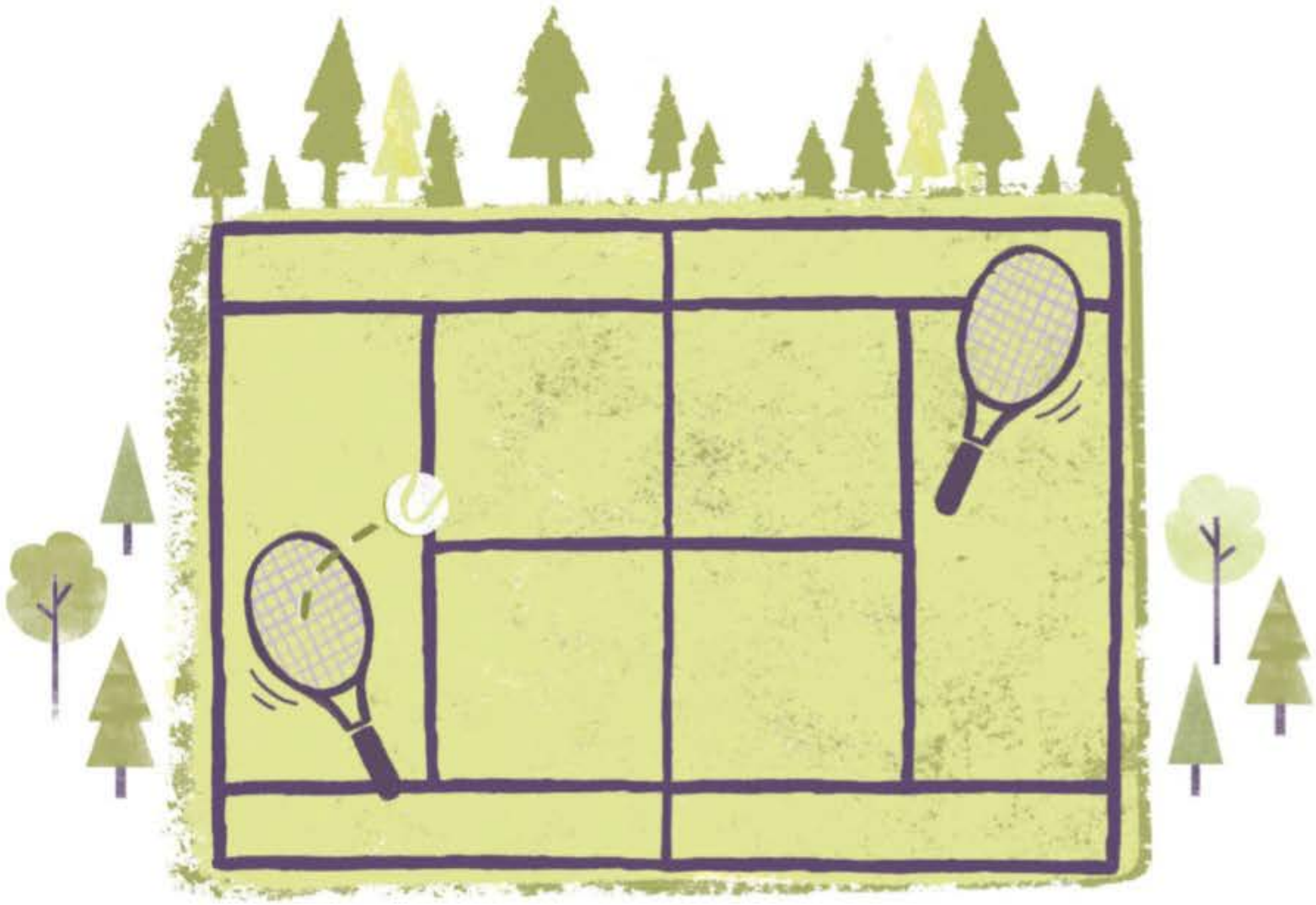

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UNFAO, Global Forest Resources Assessment 2005-2015

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